SEWER GAS

AND ITS EFFECTS.

EXTRACTS

FROM THE WORKS OF THE

LEADING SANITARY AUTHORITIES,

WITH SPECIAL REFERENCE TO THE

CONSTRUCTION AND VENTILATION OF WATER CLOSETS.

> "The Prætor took care that all sewers should be cleaned and repaired, for the health of the citizens, because uncleaned or unrepaired sewers threaten a pestilential atmosphere, and are dangerous."
>
> *Justinian's Digest*, A.D. 555.

FIFTEENTH THOUSAND.

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FROM THE

"MANUAL OF PRACTICAL HYGIENE,"

BY

E. A. PARKES, M.D., F.R.S.

" *The Air of Sewers.*—In sewers the products of decomposition are variable, as not only solid and liquid excreta and house water, but the washings and débris of the streets, the refuse of trades, &c., pass into the sewers. As a rule, the products of decomposition of the sewer-water appear to be much the same as noted above—viz., fœtid organic matters, carbo-ammoniacal substances condensing with the water of the air on cold walls, carbonic acid, nitrogen, light carburetted hydrogen, and sulphuretted hydrogen. The proportions of these gases are variable; the most common are carbonic acid and nitrogen; marsh gas is found when oxidation is impeded, and sulphuretted hydrogen and ammonium sulphide, which form in the sewer water in most cases, are liberated from time to time. The gases, however, are, as a rule, of far less importance than the fœtid organic matters, the exact nature of which it would be most desirable to examine more thoroughly."

" It is evident that, if we take the carbonic acid and sulphuretted hydrogen as indices, sewer air has no constant composition. It is sometimes almost as pure as the outside air, while at other times it may be highly impure. But these gases are probably the least important ingredients of sewer air. That organic matters are present is evident from the peculiar fœtid smell, and in some cases they are in large amount; 8,000 cubic feet of the air of a house into which sewer air had penetrated destroyed more than 20 times as much potassium permanganate as the same quantity of pure air (Angus Smith). Fungi grow rapidly in such air, and meat and milk soon taint when exposed to it. When the sewer air passes through charcoal these substances are absorbed; they may be partly oxidised, as Dr. Miller found some nitric acid in the charcoal, but they also collect in the charcoal, and can be recovered (in part at any rate) from it by distillation.

"We must also suppose, for facts leave us no other explanation, that the unknown agencies which produce typhoid fever may also be present; and there can be little doubt that cholera may occasionally spread in the same way. The poison of yellow fever (as appears likely from the epidemic in Madrid) may also exist in sewer air. Whether small-pox, scarlet fever, &c., can own a similar channel of distribution is uncertain; that dysentery and diarrhœa may also be caused by exhalations proceeding from a foul sewer we cannot doubt, but the precise agency is here also unknown."

"*Air rendered impure by the Gas and Effluvia from Sewers and House Drains.*—Cases of asphyxia from sulphuretted hydrogen, sulphide of ammonium, carbonic acid, and nitrogen (or possibly rapid poisoning from organic vapours), occasionally occur both in sewers and from the opening of old cesspools. In a case at Clapham, the clearing out of a privy produced in twenty-three children violent vomiting and purging, headache, and great prostration, and convulsive twitchings of the muscles. Two died in twenty-four hours.—("Health of Towns Report," vol. i., p. 139.)

"These are instances of mephitic poisoning in an intense degree; but when men have breathed the air of a newly-opened drain in much smaller amounts, marked effects are sometimes produced; languor and loss of appetite are followed by vomiting, diarrhœa, colic, and prostration. The effluvia which have produced these symptoms are usually those arising from a drain which has been blocked for some time. When the air of sewers penetrates into houses, and especially into the bed-rooms, it certainly causes a greatly impaired state of health, especially in children. They lose appetite, become pale and languid, and suffer from diarrhœa; older persons suffer from headache, malaise, and feverishness; there is often some degree of anæmia, and it is clear that the process of aeration of the blood is not perfectly carried on.

"In some cases I have known decided febrile attacks lasting three or four days, and attended with great headache and anorexia. Houses into which there has been a continued escape of sewer air have been so notoriously unhealthy that no person would live in them; and this has not been only from the prevalence of fever, but from other diseases. Dr. Marston, R.A., in his excellent paper on the Fever of Malta, tells us that, when typhoid fever broke out at the Fort of Lascaris, from the opening of a drain, other affections were simultaneously developed, viz., 'diarrhœa, dysentery, slight pyrexial disorders, and diseases of the primary assimilative organs.' A close examination and analysis of the affections produced by the inhalation of sewer air would probably much enlarge this list; and the class of affections resulting from this cause, to which it may be difficult to assign a nosological name, will be found, I believe, to be essentially connected with derangement of the digestive rather than the pulmonary system.

"Dr. Herbert Barker has attempted to submit this question to experiment by conducting the air of a cesspool into a box where animals were confined. The analysis of the air showed the presence of carbonic acid, sulphuretted hydrogen, and ammonium sulphide. The reaction of the gas was usually neutral, sometimes alkaline. The gas was sometimes offensive, so that organic vapours were probably present; but no analysis appears to have been made on this point. Three dogs and a mouse were experimented on; the latter was let down over the cesspool, and died on the fifth day. The three dogs were confined in the box; they all suffered from vomiting, purging, and a febrile condition, which, Dr. Barker says, 'resembled the milder forms of continued fever common to the dirty and ill-ventilated homes of the lower classes of the community.' But the effects required some time, and much gas for their production. Dr. Barker attributes the results, not to the organic matter, but to the mixture of the three gases, carbonic acid, sulphuretted hydrogen, and sulphide of ammonium, and especially to the latter two."

"The air of sewers passing into houses aggravates most decidedly the severity of all the exanthemata—erysipelas, hospital gangrene, and puerperal fever (Rigby); and it has probably an injurious effect on all diseases.

"Two special diseases have been supposed to arise from the air of sewers and fæcal emanations, viz., diarrhœa and typhoid (enteric) fever.

"With regard to the production of diarrhœa from fæcal emanations, it would seem that the autumnal diarrhœa of this country is intimately connected with temperature, and usually commences when the thermometer is persistently above 60°, and when there is, at the time, a scarcity of rain-fall. It is worst in the badly-sewered districts, and is least in well-drained districts, and in wet years. It has been checked in London by a heavy fall of rain. All those points seem to connect it with fæcal emanations reaching a certain rapidity of evolution in consequence of high temperature, deficient rain, and, perhaps, relative dryness of the atmosphere. At the same time, there is a connection between this disease and impure water. It may own a double origin, and in a dry season both causes may be in operation.

"That enteric fever may arise from the effluvia from sewers is a doctrine very generally admitted in this country, and is supported by strong evidence. There are several cases on record in which this fever has constantly prevailed in houses exposed to sewage emanations, either from bad sewers or from want of them, and in which proper sewerage has completely removed the fever. Many of these cases occurred before the water-carriage of typhoid was recognised, but yet the connection between the sewage emanation and the fever seem undoubted.

"This evidence is supported by cases in which the opening of a drain has given rise to decided typhoid fever, as well as to a very fatal disease (probably severe typhoid), in which coma is a marked symptom. So also in some instances (Windsor and Worthing) the spread of enteric fever has evidently been owing to the conveyance of effluvia into houses by the agency of unventilated sewers. In a case mentioned to me by a friend, an outbreak of enteric fever in a training-school was localised in certain parts of the school (whereas the drinking water was common to all), and was traced to imperfection of traps in those parts of the house which were affected. In this case the drains led down to a large tank at some distance, and at a much lower lever, and the smell of the effluvia was so slight that at first it was not believed that the drains could be out of order.

"These two classes of fact seem decidedly to show a causal connection between the effluvia from sewers and excreta and enteric fever, and they are supported by the statistical evidence which proves that the prevalence of typhoid fever stands in a close relation to the imperfection with which sewage matters are removed. The army statistics give excellent instances of this, and the evidence produced by Dr. Buchanan of the prevalence of typhoid fever before and after sewerage of a town is to the same effect."

FROM THE

"DISEASES OF MODERN LIFE,"

BY

DR. RICHARDSON, F.R.S.

" When emanations from a sewer or cesspool enter a house, phenomena of disease, much more decided and acute than those described in the last section, are apt to be presented amongst the inmates. The researches of the late Dr. Herbert Barker, in which I had an opportunity of taking part, have taught the nature and quality of ordinary cesspool and sewer air, and the effect of such air on animal life. They have shown that cesspool emanations, when they are steadily inhaled, are poisonous ; the symptoms of disease induced being those of intestinal derangement, followed by prostration, increased temperature of the body, distaste for food, and those general signs which mark the milder forms of continued fever common to the dirty, ill-ventilated houses of the lower classes of the community. Pursuing these researches into an analysis of the poisonous quality of sewer air, Barker discovered that the emanations were compounded of several gases, but that the true disease-producing agent was sulphuretted hydrogen gas. This gas diffused in breathing air in the proportion of 0·056 per cent.—in which dilution it is, after a time, indefinable by the sense of smell—was sufficient, even in such minute distribution, to induce diarrhœa, rapid pulse, heat of the surface of the body succeeded by coldnesss, tremors of the muscles, and all the worst symptoms that follow the inhalation of sewer air.

* * * * * * * *

" Sewer air may become the bearer of those poisons, of the spreading or communicable diseases, which are volatile and easily diffusable.

* * * * * * * *

"Typhus fever, scarlet fever, small-pox, are dependant for their existence on poisons which are much more readily transmissible by suspension in sewer air, and are more liable to be introduced into the body by the breathing organs. With considerable reserve, I may express the opinion that I have known these diseases communicated by sewer air; but the disease, *par excellence*, derived from the sewer, is that continued fever which is induced by the natural atmosphere of the sewer, by the inorganic products of organic decomposition, of which sulphuretted hydrogen plays the leading part."

FROM THE

"HANDBOOK OF HYGIENE,"

BY

GEORGE WILSON, M.A., M.D.

"*Air rendered Impure by Sewage and Cesspool Effluvia.*—Amongst the gases generated by the decomposition of fæcal matter, whether occurring in sewers or cesspools, may be enumerated, carbonic acid, nitrogen, sulphuretted hydrogen, light carburetted hydrogen, and ammonium sulphide. Dr. Letheby found that sewage-water, excluded from air, and containing 128 grs. of organic matter per gallon, yielded 1·2 cubic inches of gas per hour during a period of nine weeks. But the amount of gaseous products given off under ordinary circumstances must vary greatly, according to the dilution of the sewage, the rapidity of flow, temperature, ventilation of the sewers, etc. In comparing the results of analyses made by various chemists it would appear that the oxygen is diminished, and the carbonic acid greatly increased, but that sulphuretted hydrogen and ammonium sulphide, when present, exist only in very small quantities. The peculiarly fœtid smell of sewage-gas is therefore owing to the presence of organic matter, whose exact chemical composition, however, has not been determined. Dr. Odling believes it to be carbo-ammoniacal. It is alkaline in reaction, and speedily decolorises solutions of potassium permanganate. Like other organic effluvia, it promotes the growth of fungi, renders milk sour, and taints meat.

" It is doubtful whether the effects of sewer-air upon the health of men employed at work in sewers can be said to be very injurious. Indeed, the researches of Dr. Guy and Parent du Chalet, at first sight, go to prove that this class of labourers enjoy a marked immunity from diseases which can be attributed to sewer-emanations; but, as has been shown by Dr. Murchison, there are several elements of error in their statistics which mar their conclusions. For example, Dr. Guy's researches were made before enteric and typhus fever were fully recognised as distinct diseases, and Parent du Chalet's statistics were not only too scanty for a fair deduction, but the majority of the sewer-men whom he examined had been employed at that special work for only a short period. According to Dr. Murchison's experience, enteric fever is by no means uncommon among these men, and Dr. Peacock's inquiries led him to express a similar opinion. But whatever the issue of this question, it seems to be quite certain that constant exposure to sewer-gases diminishes the risk of being injured by them. A remarkable instance of this apparent immunity enjoyed by workmen, and the disastrous effects upon those whose exposure to such gases was only casual, is afforded by an event that occurred at Clapham in the autumn of 1829 :—20 out of 22 boys at the same school were seized with violent vomiting, purging, prostration, and fever within three hours. One boy had been seized with similar symptoms two days before, and died; another also succumbed. So alarming was the outbreak that poisoning was suspected, but, after careful investigation, it was found that the sole cause of disease was to be attributed to the opening of a drain at the back of the house. This drain had been choked up for many years, and had been opened two days before the first illness occurred. The effluvia from the drain were most offensive, and the boys had watched the workmen cleaning it out; none of the workmen, however, were subsequently attacked with any of the symptoms which so seriously affected the boys."—*Murchison.*

"While numerous other instances are recorded of the evil effects of the air of sewers, cesspits, drains, etc., in producing temporary ailments, such as nausea, vomiting, diarrhœa, and headache, the great interest which attaches to this important subject rests on the development and spread of enteric fever. Dr. Murchison, in summing up his evidence with regard to the spontaneous origin of this disease, says: 'I readily admit that we cannot succeed in tracing every case of enteric fever to organic impurities. But if the disease can be traced to such causes in a few undoubted instances, it is reasonable to infer that its causes are similar in all cases where it has a spontaneous origin. As already stated, the actual poison may, like the miasmata which gives rise to ague, be inappreciable to the senses, or by chemical research. During the last four years (1858-1862), however, I have met with few examples of enteric fever which, on investigation, I could not trace to defective drainage, the existence of which was occasionally unknown to the inhabitants of the infected locality.'

"More recent researches tend to show that enteric fever is perhaps seldom generated *de novo*, but that it is essentially a specific and infectious disease. No doubt, a great deal of the discrepancy of opinion which has hitherto existed, and still exists, concerning its etiology, is due to the difficulty of diagnosing the many different varieties of the disease. The point, however, which has especially to be borne in mind is this,—that sewers often become the real channels by which the contagium is propagated. The sewer-air, laden with the specific poison, readily finds its way into houses on account of its greater tension, and in consequence of badly-trapped or imperfectly-ventilated drains. It may be inappreciable to the senses, but its baneful effects make themselves felt none the less, and, as recent events have shown, may sometimes exhibit themselves in the most exalted stations of life. Indeed, it would appear that persons of the upper and middle ranks in towns are more liable to be attacked by enteric fever than the poorer classes, and for this reason—the houses of the former are more generally connected with sewers, and, either from structure or situation, are of higher elevation, so that the light sewer gases, in obedience to natural laws, are more apt to accumulate in the drains of such houses, and, when the drains are not efficiently trapped or ventilated, to effect an entrance into the houses themselves. Thus it happens that a system of sanitary engineering which is intended to prevent, and does prevent, the development of disease, not unfrequently furnishes the readiest means for its propagation. All this, however, could be frustrated if sewers and drains were always properly ventilated."

"One other point connected with the propagation of enteric fever deserves notice: it seems to be clearly established that the disease may be contracted by inhaling the effluvia from enteric stools previous to their being disposed of, and hence the necessity of disinfecting all such stools so soon as they are passed."—*Parkes.*

"Amongst other serious consequences of fæcal emanations, the occasional spread of cholera, and the occurrence of autumnal diarrhœa, are specially to be noted. The outbreak of cholera in the City of London Workhouse, in July, 1866, was shown by Mr. Radcliffe *(Ninth Report of Medical Officer of the Privy Council)* to have taken place, in all probability, in consequence of a sudden efflux of sewer-air from a drain containing choleraic evacuations. Autumnal diarrhœa, again, is found to prevail when the season is warm and dry, and more particulary in badly-sewered districts. In speaking of this subject, Dr. Murchison says, that 'circumscribed autumnal epidemics of enteric fever are often preceded by an increase of diarrhœa, and the diarrhœa reaches its acme long before the fever does.' After heavy falls of rain the sewers become well flushed, and the diarrhœa subsides."

FROM

"RURAL SANITARY SCIENCE,"

EDITED BY

LORY MARSH, M.D.

" Diphtheria is a disease peculiarly fatal to children, and owes its origin to the breathing an atmosphere tainted by putrefying sewage, or, as it is commonly called, sewer-gas. The Public Health Association of New York have come to the conclusion that it selects certain localities subject to 'certain conditions of soil, drainage, and sanitary wants of dwellings which admit of preventive measures.' Mr. Oakeshott, the medical officer of health for Hornsey, has traced the cause to the escape of sewer gas into houses. One case occurred at a small school held in a room ten feet square with a sink in it. The traps to this sink were defective, and the rush of sewer-gas into the room was from two to three cubic feet per minute. Again, on examining the National Schools at Fortis Green, where the disease had appeared, he found a pit in the rear full of foul soil, the stench being very bad. The married-quarters of the Royal Artillery on Woolwich Common, consisting of a row of badly-drained cottages, had to be cleared of their inhabitants in the spring of 1875, owing to the fatal prevalence of this disease."

" Dr. Lyon Playfair has informed us that 'dryness and well-ventilated rooms are powerful means to prevent, as they are to retard, consumption.' Bronchitis and inflammation of the lungs are also largely due to the breathing impure air."

FROM A

LEADER IN "THE TIMES,"

SEPTEMBER 22ND, 1876.

" We have expended enormous sums of money of late years on the efficient drainage of towns and the proper construction of public sewers, and, no doubt, our efforts have resulted in incalculable benefit to the community at large. But while we have been directing all our energies to the task of carrying off the refuse matter which reaches our sewers, and disposing of it in a harmless, if not in a profitable manner, we have as yet taken little thought of the means whereby the matters we want to get rid of are to be conveyed innocuously from our houses to the sewers. It is much easier to reform town drains than house drains; the former are made to be got at easily, and at the worst can always be reached at a cost of a temporary suspension of traffic. But house drains, especially in old houses, are to be found no one knows where; and even in new houses, the perversity or ignorance of builders often places them where they are practically inaccessible. Out of sight out of mind is too often the easy-going maxim of builder and tenant alike; and it is frequently not till another sense is forcibly called to take cognizance of what the sight has neglected that the householder finds, to his cost, that the drains are out of order. Few builders can be trusted to make the connections between the house drains and the public sewers satisfactorily, and, unfortunately, it is a matter which most architects seem to think beneath their notice. But even if that particular matter has been thoroughly attended to, the danger is by no means at an end. *All house drains need to be ventilated*, and wherever it is possible their connection with the external sewer should be broken by a simple expedient, known to all builders, but, unhappily, adopted until quite recently by few or none. Thus in too many cases the improvement in public sewers has as yet been a bane as well as a benefit, because it has not been accompanied by corresponding attention to sanitary precautions within the house.

"It cannot be too strongly insisted on that the universal extension of a general and public system of drainage in large towns calls more imperatively than ever for vigilant attention to domestic sanitary arrangements. Formerly, when every house more or less disposed of its own drainage, though matters were bad enough, yet the extent of the mischief could generally be measured. Now, however, each house, unless specially protected, is exposed to the attacks of the sewage of the whole town, and yet, as a rule, no greater precautions are taken than heretofore to keep the enemy at bay. The evils to which the unwary householder is exposed are neither few nor easy to guard against. If his house is an old one, drains are hidden away in a manner which conclusively proves that malice is no match in ingenuity for ignorance. Some of them are sure to be found with all connections closed save that which furnishes them with a constant supply of noisome and fetid matter. Sometimes the outlet of the old cesspool is closed when the house is connected with the public sewers, but the builder has carelessly left open to the house all the old drains which formerly fed the cesspool; or the new drain is laid with a broken pipe or a defective joint, and fills the house with stench and poison. Indeed, where a house has exchanged the old system of drainage for the new, it needs an almost superhuman vigilance to guard against the various and subtle sources of future mischief; yet the task is generally left to a careless builder and to blundering workmen. In a new house the dangers are not, perhaps, so numerous nor so difficult of detection, but they are real and serious enough. The great object of builders seems to be to get the drainage out of the house in as closely-sealed channels as possible.

This is a good thing with proper precautions, but they forget or refuse to acknowledge that where water can pass gas can pass too, and that while the natural flow of water is downwards, *that of this particular gas is upwards. Consequently, the drains, unless ventilated as well as trapped, are so many channels whereby sewer gas is laid on to the interior of the house.* Now, sewer-gas has a very bad character, and, for all we know, its character may be worse than it deserves; that, however, is not a question for us, and the connection of sewer-gas with specific disease we are content to leave to professional experts. At any rate, all will admit that sewer-gas is a very unpleasant companion in a house, more especially when a good deal of money has been paid to keep it out. Yet, with all our efforts at sanitary improvements, there are still very few houses in towns where it is not at least an occasional visitor. Builders will insist on the efficacy of water traps and cemented pipes, and, no doubt, such expedients are good so far as they go. But, of course, gas will pass through water under sufficient pressure, and, not to speak of the pressure which the unaided gas often exerts on the outside of the trap, it is often powerfully aided from within by the difference of temperature which exists between the house and the external drains. In fact, we not only lay on the gas from the large reservoirs we have constructed in every street, but we often turn our houses into ingenious pumps to suck it in. The remedy for this is not only to trap all drains, *but to ventilate them as well. If from below the trap a pipe rises to a convenient distance in the open air, the gas is forced through it whenever the pressure becomes excessive, and the trap, relieved from this pressure, becomes a protection, and not a snare.* This remedy is as simple as it is effective; yet it would be interesting to know the percentage of houses in any large town whose most noxious drain-pipes are ventilated as well as trapped.

"Even if all new houses could be effectively drained, the danger would still beset us in our present habitations. We cordially sympathise, therefore, with the efforts of the Society of Arts, for nothing but benefit can come from a public discussion of the question, from the interest it will arouse and from the knowledge it will diffuse."

EXTRACT FROM PAPER,

BY

W. OGLE, M.A., M.D., F.R.C.P.,
Physician to the Derbyshire Infirmary,
Read at the Congress of the Sanitary Institute of Great Britain,
Stafford, October, 1878.

* * * * * * * *

It is now a thoroughly established fact that typhoid fever arises from sewage. It would be well if it were called "sewage-fever," instead of being masked by such terms as "gastric fever," or even by the title "typhoid." At present I have three cases in mind, all cases of typhoid fever, one a poor man, one the child of a clergyman in good circumstances, and one the head of a wealthy family. In each of these cases, everything has been done or is being done to secure recovery, but in each case the idea of prevention would never have been thought of had I not gone considerably out of my way to urge it. In one of the three, I am thankful to believe that the adoption of preventive measures has been the result of my interference. I have just received the following satisfactory letter:

"Dear Dr. Ogle,—Thank you very much for your report; I have to-day set men on to work at our water supply, and when the job is finished, will send you a bottle of water to test again. I find that the water flows a long way through wet ground in a mere rubble drain, just below the surface. At the same time, I have had the drains up, and find that an overflow pipe from our boiler-supply cistern communicated *direct* with the drain below the main S trap. This accounts for the drain smell in its neighbourhood. I have now made all the kitchen drains discharge into the open air through the kitchen wall, where the overflow is caught by a trapped drain.

"Yours gratefully, * * *"

In this case, therefore, I have succeeded; and when I tell you that in that very house some years ago, there was, I believe, a death from typhoid fever, you may judge that it was time for something "preventive" to be done.

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FROM

"SANITARY ENGINEERING,"

BY

BALDWIN LATHAM, C.E., M. Inst. C.E., F.G.S., F.M.S.

The evil effects arising from the non-ventilation of sewers appear, after the revival of sanitary science in this country, not to have received any marked attention; the reason probably being that towns generally were in so bad a sanitary condition, as to make it difficult to separate the causes which led to atmospheric pollution and the propagation of disease. So general were nuisances, and so impure had the air of towns been rendered, it is not surprising to find that, until sewerage works were carried out, and the principal nuisances had been abated, the ill effects of non-ventilation of sewers became apparent. Present experience shows that there is something in the air of sewers that is dangerous to health, and pestilent to life itself, and that it is imperative, by proper ventilation, to dispose of, or neutralize the effects of its deadly influence. It should be laid down as a rule that all sewers must be ventilated, as unventilated sewers may be as dangerous as steam-boilers without safety-valves. * * * *

The author does not wish to convey the impression that unventilated sewers are always the cause of disease; but, what he does desire to impress upon all is, that in the absence of ventilation there is great danger of sewer-air entering our habitations; and, although this sewer-air may not, *per se*, be the cause of disease, nevertheless, the effect of breathing such air is to produce a state of malaise, and render those that breathe it less able to withstand the onslaught of disease. A few years ago, the author had an opportunity of seeing what the effect of sewer-air was in an hospital in London. This hospital had become so unhealthy that the surgeons declined to perform operations, as the wounds would not heal, and, generally, the patients did not do well. The hospital was closed; and an examination made by the author revealed the fact that the building was largely aerated direct from the sewers. It was re-drained, and the direct communication with the sewers cut off, and again opened, and has since been used with great advantage to those resorting to it. * *

In the year 1870 an outbreak of scarlet-fever occurred in a market-town in Kent; and, in making an investigation, the author found a row of detached houses, in every one of which there was scarlet-fever, and yet no communication had taken place between the various occupants. Upon inquiry, it was found that a case of scarlet-fever was imported into one of the houses, and the disease rapidly spread to all the others. All the houses were drained by one common sewer into a cesspool; no provision was made for the ventilation of the drains, and a branch-drain was brought within each house. All the drains were either untrapped or imperfect, so that any gases present in the sewer or cesspool must pass into the house as the only mode of escape; in fact, the method of draining into the cesspool, as in this case, was similar to that of draining into a bottle, all the liquid and solid matter passing into the drains, liberating an equal amount of the foul air, conveying, no doubt, the germs of disease which escaped into the houses.

In the author's experience, stoppages in the sewers of a large town, which have had the effect of causing an increase of pressure in the sewer-air, have not unfrequently been found to coincide with an outbreak of disease in houses which were affected by the stoppage.

In a system of unventilated sewers, every house in a district is placed more or less in communication, and, as a natural consequence, diseases may be transmitted from house to house by the sewers and drains, as evidenced in the case already referred to. If further evidence were needed as to the ill effects of sewer-air, this fact is often forcibly brought to our attention by the loss of the lives of men who are employed to work in our sewers, or in the confined places in which sewage is treated; but, it should be here noted, that the cause of these deaths is traceable to the chemical impurities of the air of the sewers as distinguished from that more general impurity which escapes detection, but which is believed to be the cause of disease.

"THE LANCET," June 1st, 1878.

DIPHTHERIA IN NORTH LONDON.

Diphtheria has for some months shown an excessive fatality in the northern districts of the metropolis. Since the beginning of the year, no less than 24 deaths from this disease have been recorded within the registration sub-district of Hampstead, which includes a considerable portion of Kilburn. Of these 24, 7 were registered in the week ending May 25th, of which 3 occurred in one family. During the same period, 16 fatal cases were registered in Hackney, 15 in Islington, and 10 in St. Pancras; several have also been recorded in the northern parts of Marylebone, especially in St. John's-wood. Outside registration London, too, the disease has shown epidemic prevalence; 12 fatal cases have, since the beginning of the year, occurred in Hornsey, 9 in Finchley, 5 in Tottenham, and a few others in Enfield and Edmonton. A large proportion of these fatal cases have occurred in houses of a superior class, thus affording evidence in support of the theory that sewer-gas plays an important part in the causation of diphtheria. Dr. J. B. Russell, the medical officer of health for Glasgow, has recently called attention, in an elaborate paper, to the intimate relation between the fatality of diphtheria and the amount of communication with sewers (through water-closets, sinks, waste-pipes, &c.), existing within the Glasgow houses. He points out that, whereas the fatality from all zymotic diseases, except diphtheria and enteric fever, is greatest in the poorest tenements of one or two rooms, the mortality from diphtheria and enteric fever is greatest in the better class houses, where internal communications with the sewers more frequently exist. The extent to which the atmosphere of most town residential houses is poisoned by sewer-gas is far too generally overlooked.

HINTS ON THE CONSTRUCTION OF WATER CLOSETS.

" *Efficiency of Traps.*—Supposing, of course, they are properly laid, a trap is efficient, if water stands in it to the height of $\frac{3}{4}$ inch above openings, if water passes through it sufficiently often, and with force enough to clear out the receptacle and renew the water in it. But traps are often ineffective —1*st*, From bad laying, which is a very common fault. 2*nd*, From the water getting thoroughly impregnated with sewer effluvia, so that there is escape of effluvia from the water on the house side. 3*rd*, From the water passing too seldom along the pipe, so that the trap is either dry or clogged. 4*th*, From the pipe being too small (2 to 3 inches only) and 'running full,' which will sometimes suck the water out of the trap; it usually occurs in this way, as frequently seen in sink traps: the pipe beyond the trap has perhaps a very great and sudden fall, and when it is full of water, it acts like a syphon, and sucks all the water out of the trap; to avoid this, the pipe should be large enough to prevent its running full, or the trap should be of larger calibre than the rest of the pipe. 5*th*, Traps may perhaps be inefficient from the pressure of the sewer-air, combined with the aspirating force of the house so displacing the water and allowing the air uninterrupted communication between the sewer and the house. The extent of the last danger cannot be precisely stated. In a long house-drain which got clogged, and in which much development of gaseous effluvia occurred, there might possibly be for a time a much greater pressure, but whether it would be enough to force the water back, with or without the house suction, has not been yet experimentally determined. But the reasons already given show that we ought not to place dependence solely on traps, though they are useful adjuncts.

"Rain-water pipes are sometimes used to ventilate drains, but, independent of their small size, which often leads to blockage, they are often full of rain, and cannot act at the time when ventilation is most required.

"THE VENTILATION OF THE SOIL-PIPE IS A MATTER OF IMPORTANCE, AS THE WATER FROM THE PAN SUDDENLY DISPLACES A LARGE BODY OF FOUL AIR WHICH RISES THROUGH THE SYPHON AS THE WATER FLOWS."—*Manual of Practical Hygiene, by Edmund A. Parkes, M.D., F.R.S.*

——o——

"Generally speaking, those closets are the best which provide for good flushing and rapid and complete removal of the excreta, without permitting reflux of foul air. The pan should be roomy and made of white glazed earthenware. The machinery should work easily, and not be apt to get out of gear, and the seat should be so framed as to come asunder readily to permit of inspection."—*Handbook of Hygiene, by George Wilson, M.D.*

——o——

"The requirements of a good water-closet are, that it shall be inodorous, shall work efficiently with a minimum quantity of water, and shall be simple in construction, and not liable to get out of order. * * * * * It will be found in practice that some of the simplest * * * are the best; in fact, all those closets consisting of a simple basin and trap, * * * * if provided with ample water for *flushing*, can be used without causing any nuisance, *as there is no space for noisome gas to accumulate, and no exposed area plastered with fæcal deposit to generate foul gas; and if the closet is provided with ample ventilation,* * * * * *no gases can pass back through the trap to cause any mischief.*"—*Sanitary Engineering, by Baldwin Latham, C.E.*

DODD'S

Patent Ventilated Water Closet

Will be found to approximate more closely to the ideas of Dr. Parkes and Dr. Wilson, as to what a Water Closet should be, than any other Closet now before the public.

* * *

It possesses, amongst others, the following advantages over most Closets now in use:—

1. **Great simplicity.** Being valveless, and having no other mechanical appliance or arrangement, it cannot possibly get out of order, *and, if once properly fixed, will remain for years in good working condition without any skilled supervision.*

2. The **ventilating** orifice is as large as the closet will allow, and, being placed above the water in the trap, at once relieves this from pressure of sewer-air or gas, and provides a ready outlet for the latter, *thus insuring perfect freedom from sewer-gas, and the many ills that can be traced to its admission into dwelling-houses.*

3. The position of the ventilator prevents the *possibility* of the closet ever becoming unsyphoned or untrapped.

4. The excrement being received at once into water, becomes to a great extent deodorised.

5. Being free of all metal on which the excrement can act, it is perfectly free from *closet gas*, so common where the pan and valve closets are used.

Special advantages of the **A** *Closet are—*

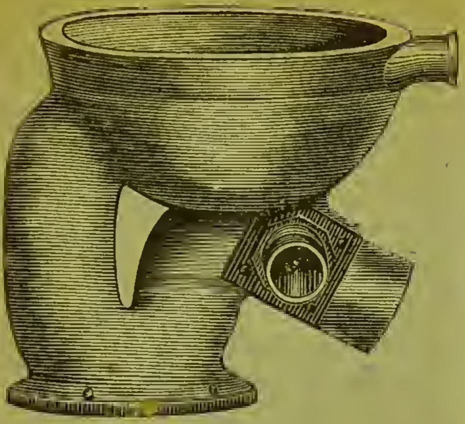
1. The outlet being at the front, and almost hid from the sight by the woodwork of the seat, it presents a less offensive appearance to the eye than any other closet now in use.

2. The position of the outlet is such as to receive the urine at once, thus obviating the use of the lead apron, so commonly specified by architects to prevent the urine passing between closet basin and under part of seat.

Special advantages of the **A A** *Closet.*

In addition to those of the **A** Closet, are—direct or straight outlet at the back, thus enabling the plumber, when next an outside wall, to fix the closet on the floor without either lead bend or wooden step.

CLOSET A A.



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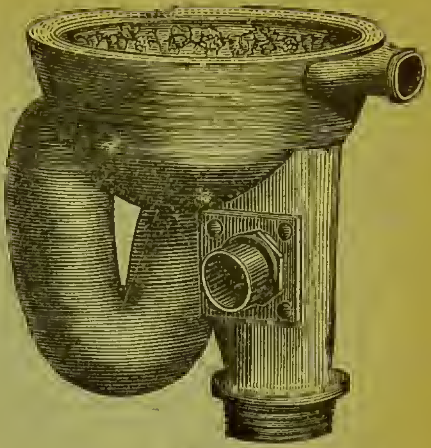
CLOSET A.



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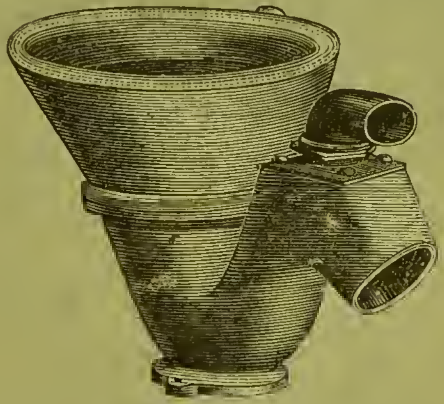
CLOSET B, BASIN AND TRAP IN TWO PIECES.



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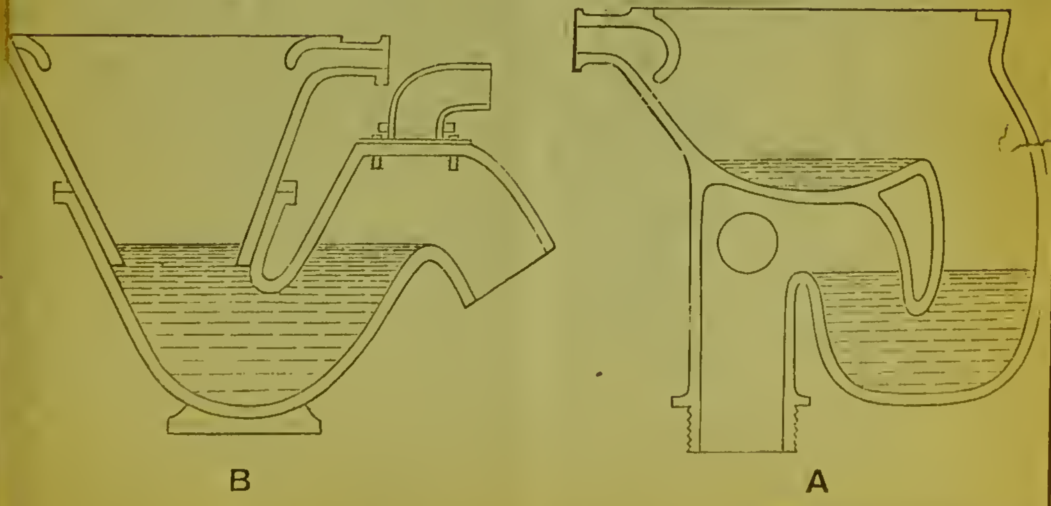
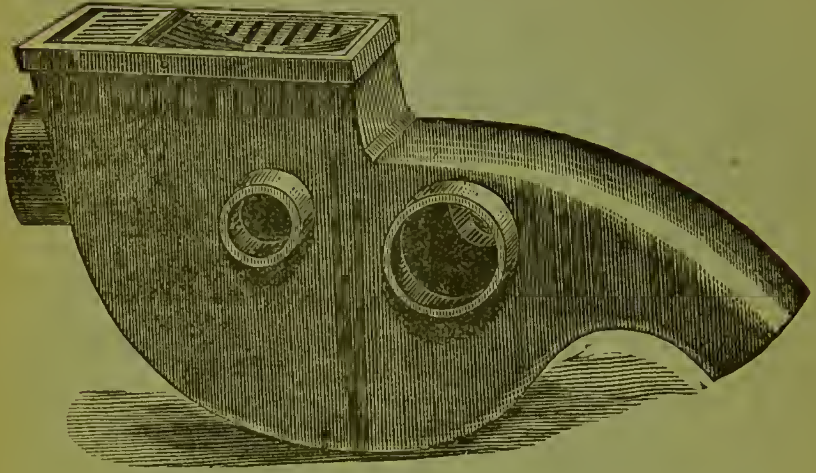
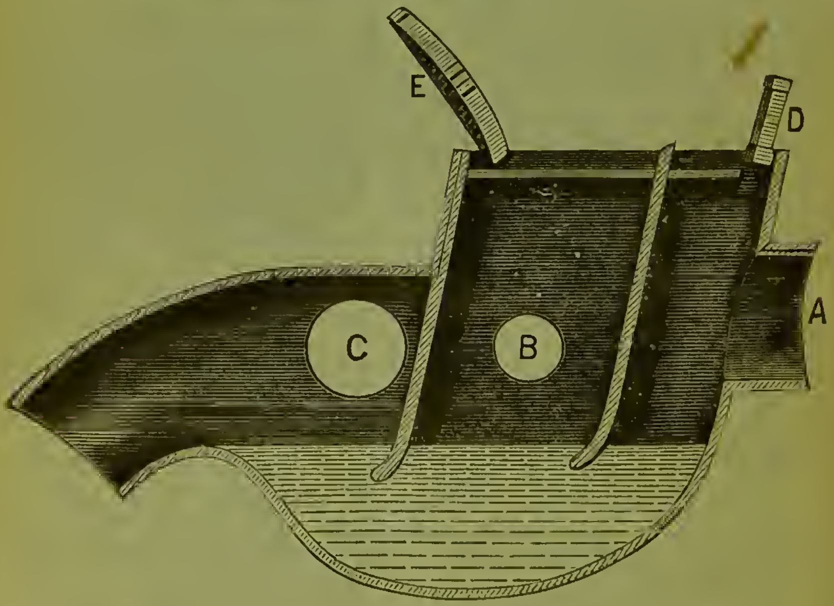


DODD'S

PATENT DUPLEX STENCH TRAP.





A. Inlet for Soil-pipe from Closet. **B.** Inlet for Waste from Bath, Lavatory, or Sink. **C.** Inlet for Rain-water, or for Sewer-Ventilation. **E.** Grating, to receive Surface Drainage. **D.** Grid, allowing current of air to pass up Soil and Closet Ventilating Pipes.

JOHNSON AND TESSEYMAN, PRINTERS, MICKLEGATE, YORK.

THE ARTIZANS' DWELLINGS BILL.

Remarks by H. W. Freeland, at a Meeting of the Social Science Association, March 8th, 1875.

WHATEVER defects may be discovered in the Artizans' Dwellings Bill, and whatever its shortcomings may be, the country has, I think, reason to be grateful to the Minister who has been bold enough to state plainly the magnitude of the evils which are staring us in the face, and to make, at all events, an earnest and conscientious effort to grapple successfully with them. We are told by the Home Secretary that, while the death-rate for the whole country is about 22½ per 1000, in London it is 24; that in Manchester it has been 30, in Sunderland 37, and in Liverpool during the last ten years 38. We are told by the same authority that in one district in Manchester it has been as high as 67; and in another district, now swept away, as high as 70 in the 1000; that in one district in the same city, out of 100 deaths of persons of all ages, the deaths of children under five years reached the rate of 49·7; and that in Liverpool matters are even worse. Dr. Ross, to whom we are deeply indebted for his valuable and suggestive paper, tells us that there are streets and courts in this metropolis where the mortality will run up in some years as high as 70 in the 1000. These are facts which must, I think, make every one feel, not only that there are plague spots in some of our wealthiest cities, but that there are blots on England's civilization and greatness which every Englishman must wish to see removed; I had almost said, no matter at what cost. These facts will, I trust, make all now present, and Members of both Houses of Parliament, anxious to make Mr. Cross's Artizans' Dwellings Bill, by suggestions and amendments, as complete as under the circumstances it can be made. As regards the amount of good to be done by such a Bill, we must remember that it will have many obstacles to encounter;—the cost will be great—local authorities are often, in their corporate or individual capacities, interested in the dwellings requiring removal—they, as well as the medical officers and ratepayers, will, I fear, hesitate long, at all events in the provinces, where local taxation is often heavy, before they will look an immediate loss and burden in the face. The introduction of an alternative moving power, such as Dr. Ross spoke of, will, I think, at all events, in the provinces be required. On the question of COST, however, ratepayers have been well reminded that nothing is so costly as sickness, and that "health is wealth." Ratepayers, also, will do well to remember that the costs of crime in prisons, of sickness in hospitals, and of lunacy in lunatic asylums, will no doubt in the end be largely diminished. As regards the provisions in the Bill for diminishing legal expenses, they are excellent as far as they go, but I venture to think that they might be carried much farther. When a provisional order has been obtained, I cannot but think that it might be laid on the tables of the Houses of Parliament for forty days, and then, if no action were taken, acquire the force of law, as if it had been inserted in the original Act. Notices of such provisional orders having been laid before Parliament should, I think, also be inserted in one or two of the local papers of the district concerned. I entirely approve of the provision in clause 20 of the schedule, giving to a receipt for purchase-money the effect of a conveyance; but I object to the retention of the *ad valorem* Stamp Duty. The Bill is one of an entirely exceptional character ; it throws a heavy immediate burden on localities, and the transactions which may take place under it are not, I venture to think, transactions from which the Government ought to derive any profit in the shape of a duty. I agree with my friend, Mr. Godwin, in thinking that the provisions as regards arbitration might be improved. Each party should, I think, be at liberty to name an arbitrator, if they cannot, to save expense, agree on one to act for both parties. The arbitrators, if there be two, should name an umpire, or, if they cannot agree on one, the Secretary of State or perhaps the confirming authority generally should name one for them. To prevent too frequent a recourse to umpirage, the costs of it should, I think, be borne by the losing party, the local authority or the parties paying the costs of simple arbitration. This arrangement would supersede the necessity of a costly and haphazard experiment of an appeal to a jury. The power to take adjoining lands *by agreement* for the purpose of rendering a scheme more complete or of diminishing the probable loss, for loss there will be, is, I suppose, sufficiently provided for by the 13th clause of the Bill. If not a few words might be added. I think that Mr. Cross proposes to add them. I am glad that the Public Works Loan Commissioners are to be empowered, by section 16, to advance money for the purposes of the Bill, repayable within fifty years, but I think that the maximum rate of interest should be fixed definitely by the Bill and not be left as now proposed, variable from 3½ per cent. upwards at the discretion of the Treasury. The main difficulties in the way of carrying out the benevolent intentions of the Act appear to me to arise under sections 5 and 7 of the Bill, requiring that dwellings for the persons displaced shall be erected within or near the area cleared, and providing that the local authority shall not, at all events in the first instance, erect such dwellings. I do not believe that private speculators will ever be able to erect dwellings suitable for, and, as to rent, within the reach of the class of persons who under this Bill will be displaced so as to yield anything like a commercial result. We must hope, however, that having regard to the magnitude of the evils, private munificence and the action of societies, such as those in London which have been referred to, will step in. In section 5, after the words "or in the vicinity thereof," I would suggest the insertion of these words, "or in such other locality as shall be conveniently situated for the trades or occupations in which such persons or the majority of them shall be engaged." At the end of clause 5 and of clause 7 I would insert these words, "including a supply of water to be laid on for each separate set of rooms, wherever a building is intended to be let out in separate apartments." I have glanced at some of the obstacles which the Bill will have to encounter. There are other and very serious difficulties which any improvement of artizans' dwellings has to encounter, more especially as far as London is concerned. I allude chiefly to the difficulty of obtaining sites for the erection of such dwellings, and the difficulties arising from tenure. In London not only is it difficult to get sites, but it is difficult even for the upper classes to get a freehold at all. This, I think, leads them to take less personal interest in the improvement of the metropolis and of artizans' dwellings than they probably would do if they were freeholders. I cannot now enter fully into this question, but I wish to quote a few remarks, with which I agree, from a paper by Sir George Campbell, in the *Fortnightly* for January in the present year on the "Tenure of Land:"—

"It is every way inexpedient, and contrary to public policy, that the ambition of a few families to create unwieldy properties in the future should so hamper and encumber enterprise as is eminently the case in the metropolis. It would be very justifiable and very desirable to allow every holder of a long building lease to buy the freehold at a fair valuation of the reversionary interest. The rule might be that in every case in which land is leased for a period beyond the term of an ordinary agricultural lease, and is covered with buildings of a certain value in proportion to area, the leaseholder should have a right to enfranchise the tenure. No one can look around him in London without seeing the disadvantages which so frequently attend the limited leasehold tenure."

Another very serious obstacle to improvements in the direction indicated arises from the quantity of land held in mortmain. Why should Governments or Parliament sanction a land-buying or landholding policy on the part of Ecclesiastical corporations or the Ecclesiastical Commissioners? And why should the Charity Commissioners be suffered to throw obstacles in the way of sales of charity property, even where the trustees are willing to sell or enfranchise, by requiring forty years' purchase to be asked, and more where there is a prospect of land being built on, because they say that charity land must not be supposed to be in the market?

The argument sometimes used for retaining land, 'that it will probably rise in value, while other securities may fall,' amounts in substance to this, that land should be locked up for the possible benefit of the unknown objects of a charity or ecclesiastical investment, who may come into existence a hundred years hence, to the detriment of proprietors who might improve the land, as well as of the public requiring, for various reasons, a commodity of which, in England, the supply is very limited.

There is an excellent article on this part of the subject in the *Times* of April 29, 1872, from which I will ask leave to quote one short passage:—

"Why should not all the real property—that is, all the houses and land, and all the charges on land—now held in mortmain for the purpose of endowment, be rescued from the perils such estates are liable to, by being sold and the proceeds properly invested in the names of official trustees? There can be no doubt that the sale would be generally much to the advantage of all parties interested in every way. Estates held in mortmain cannot be managed properly and with justice to all the parties concerned. They are neglected, to the loss of revenue and value; or they are over-nursed for the benefit of tenants and underlings, not without jobbery; or they are managed magnificently and unprofitably; or the nature of the management and the uncertainty of the tenure take away all motive to improvement. Anyhow, one very large element in value is lost by mortmain."

There is also an excellent speech made by the present Lord Derby at a meeting of this Association held on the 5th of July, 1869, from which I will only quote one extract:—

"All agreed that, as a general rule, it was not desirable that landed estates should be perpetually tied up in the hands of public trustees, or for public purposes, and it was a matter, at least worthy of consideration, whether it would not be well in future to impose upon all founders beforehand some particular manner in which the endowment should be invested. If they continue to allow any individual to dispose in perpetuity of a sum of money as at present, it did not seem an unreasonable limitation to insist that the capital should only be invested in one way, namely, in the public funds. Of course it would be a difficult thing to apply such a rule to charities or endowments already existing, but with regard to future endowments he saw no hardship in such a proposal."

And now I must wish the Bill God speed; difficulties it may have to encounter, but difficulties are made to be overcome. If this Bill, when amended, becomes law and causes the destruction of unwholesome dwellings, and to some extent, at all events, supplies the place of them with better ones, it will do more, so far as its action extends, by making homes attractive and wholesome, to diminish drunkenness and crime, than any over stringent and generally futile attempts to make men temperate by Act of Parliament—it will do more for the material well-being, and for the consequent moral elevation and happiness of the working classes, than all that political reformers, however extensive—than all that trades unionism and strikes however protracted, than all that educational nostrums, missions, and the teachings of catechisms and dogmas have ever done, or, indeed are ever likely to do. The improvement of the dwellings of the working classes lies more deeply at the root of their elevation in the scale of civilized humanity than any one or all of these. If you raise the standard of their material well-being—if, as far as legislation or public or private efforts can go, you make cleanliness and health the normal condition of the working classes, Godliness will spring up as from a soil congenial, and with these will come those higher moral and intellectual aspirations—which emancipate human beings from the tyranny of the coarser sensual gratifications, and which indeed distinguish man from the brute.

ON THE

EMPLOYMENT

OF THE

FECAL MATTERS OF SEWAGE,

FOR THE MANUFACTURE OF

CEMENT,

TOGETHER WITH A COMPARISON OF THE DIFFERENT METHODS OF UTILISING THEM, AND SHOWING THE SUPERIOR

COMMERCIAL AND SANITARY ADVANTAGES OF THE CALCINATION AND CEMENT PROCESS.

For Private Circulation only.

LONDON:
PRINTED BY NISSEN, PARKER & ARNOLD, 43, MARK LANE.
1872.

Difficulty of dealing with the sludge or slush.

3. The chief difficulty of the Sewage problem consists not so much in the removal of these fecal matters, or "slush," as in the successful treatment of the slush after it has been deposited. If it is removed by subsidence or some rough species of straining or filtration (if anything further be attempted in the way of filtration than the separation of the coarser fecal matters the filters rapidly choke), it is very difficult to dry, for slush consists chiefly of organic matter which retains its water with great obstinacy, and in the process of drying, unless mixed with much mineral matter, emits a horrible stench. Moreover, when dried, it is all but valueless as a manure, and is quite so for any other purpose but fuel.

Slush, a poor fertiliser.

4. If the slush is removed by precipitation through the addition of fertilising chemicals, these fertilising elements become necessarily laden with so large a quantity of worthless matters as to reduce greatly their original value. The manures so prepared, in fact, will barely meet the expense of removal. None of the plans hitherto attempted or proposed will carry down with the slush more than a very small percentage of the fertilising elements dissolved in the Sewage water.

Estimated value of slush.

5. The Rivers Pollution Commissioners, in their report on the A B C process, say: "The value "of the solid manures obtained by treating the "Leicester Sewage with lime has been estimated, "from the analysis of Voelcker and Versmann by "Hofmann and Witt, who give the following "numbers:

	VOELCKER		VERSMANN
"Value per ton. .	15*s* 5*d*	. .	17*s* 0*d*

"Such is the value of these deposits as estimated "from chemical analysis; but experience has "warned the manufacturer of these feeble manures "that the value indicated by chemical analysis "cannot be counted upon in the market. Thus "the Leicester mud is actually sold for 1*s* per ton, "although its indicated value is from 15*s* to 17*s*. "Indeed, without fortification with sulphate of "ammonia, nitrate of soda, or superphosphate of "lime, such manures are scarcely saleable." But the original value of fertilising elements will in fact be diminished in proportion to the amount of the valueless slush with which it is mixed, and in the words of Krepp, "Solids extracted from fluid "Sewage cannot be manufactured into dry manure "so as to pay for the trouble."

Processes for utilising slush.

6. There are, however, still four processes prominently before the public, for making manure from the slush of Sewage:

a. The Carbon or Weare's Filtration process.
b. The A B C process.
c. The Phosphate of Alumina process
d. The Sulphate of Alumina process.

Weare's Filtration process.

7. The Weare Filtration process has been tried at the Workhouse at Stoke-upon-Trent on the Sewage of 650 or 700 persons. The peat charcoal used is one ton per week, and an equal quantity of cinders is added to it to make the filters. After the removal of the grosser suspended matters, the Sewage

is passed through a series of filters of increasing fineness. When the filters are full of the matters arrested, their contents are made into manure with the assistance of soot, sulphuric acid and ammonia. For this process a population of 100,000 persons would require no less than 20 tons of charcoal and 20 tons of cinders per diem, and these materials, with the slush, &c., would yield from 30,000 to 35,000 tons of manure per annum! When it is remembered that charcoal is not itself a fertiliser, and the results of analysis do not show that it removes from the Sewage water its "principal "material and fertilising elements (see Dr. Hill's "Report to the Birmingham Sewerage Enquiry "Committee), it appears improbable that the "intrinsic value of so bulky a manure, although "fortified with some extraneous fertilising ele-"ments, could be adequate to meet the expenses "of the process." Dr. Letheby estimates the cost of the peat charcoal at £3 5*s* 0*d* per ton.

The A B C process.

8. The A B C process has been more largely tried, and has been made the subject of special enquiry by the Rivers Pollution Commissioners. The process consists in treating Sewage with a mixture of Alum, Blood, Clay and Charcoal, and various other ingredients in smaller proportions. After a perfect mixture by machinery with these ingredients, the Sewage flows into tanks, when the precipitation is allowed to take place.

Amount of A B C deposit.

9. In operating upon 252,352 gallons of Leamington Sewage with this process, the Commissioners estimated that the following weight of

dry manure was produced. — *Rivers Pollution Commissioners' Report* (1868).

" Suspended matters in Sewage " operated upon	1,052 lbs.
" Insoluble matters added in " A B C mixture	925 ,,
" Soluble matters precipitated " by action of A B C mixture	276 ,,
" Total manure dried at 100°	2,253 lbs."

R. P. Commissioners' estimate of value.

10. The Commissioners estimate that if air-dried only, the weight of this quantity of manure as sent to the market would have been 2,435 lbs., and that its value estimated on its chemical composition would be £1 14*s* 9*d*, " but appraising it " at the value which it will, according to Messrs. " Lawes and Gilbert, fetch in the market, it is not " worth one-third of that sum."

Cost of production.

11. It is then stated by the Commissioners that, " besides labour, fuel, wear and tear, and interest " upon plant, there was expended in the pro- " duction of this manure :—

" 577 lbs. Ammonia Alum, at " £7 per ton	1	16	1
" 34 lbs. Epsom Salts, at £1 " per ton	0	0	4
" 26½ lbs. Animal Charcoal, at " £6 per ton	0	1	5
" 34 lbs. Vegetable Charcoal, " at £2 per ton	0	0	7
" 1,155 lbs. Clay, at		—	
" 7 lbs. Blood, at		—	
	" £1	18	5"

R. P. Commissioners' opinion on process.

12. The Commissioners therefore report that: "The manure obtained by this process has a "very low market value and cannot repay the "cost of manufacture."

The Phosphate of Alumina process.

13. The Phosphate of Alumina process (Forbes and Price) consists in treating the Sewage with that mineral dissolved in sulphuric or hydrochloric acid, by which means the effluent water becomes enriched by that portion of the soluble phosphate which is not precipitated, or if not intended for irrigation, the whole of the phosphate may be thrown down with lime.

Dr. Voelcker's analysis of deposit.

14. Mr. Marshall, the Engineer of the Board at Tottenham, and Dr. Voelcker supply some details by which the probability of this process paying its expenses may be estimated. Dr. Voelcker analysed a portion of the deposit precipitated by himself on the 6th April, 1871, and found that *after drying it at 212°*, it contained :—

	Dried at 212° Faht.
* Organic matter and water of combination	24·90
† Phosphoric Acid	5·75
Lime	29·70
Oxide of Iron and Alumina......	12·16
Magnesia, Carbonic Acid, &c....	20·20
Insoluble silicious matters	7·29
	100·00

* Containing Nitrogen	1·03
Equal to Ammonia	1·25
† Equal to Tribasic Phosphate of Lime	12·55

Dr. Voelcker's valuation of deposit.

15. Dr. Voelcker states that in the dried state in which it was analysed he considers it worth from £2 10*s* to £2 15*s* per ton. "In an air-dried "and powdering condition, in which it would have "to be sold to the farmer, the deposit probably "will contain from 12 to 15 per cent. of moisture, "for which allowance has to be made in estimating "the value of this Sewage manure." In other words, the above sample represents a manure which, as sold in the market, could not have a greater value certainly than £2 10*s* per ton, and might fall as low in value as £2 2*s* 6*d*.

Cost of process for 1 million gallons.

16. Mr. Marshall says: "The cost of forming "this precipitate and preparing it for sale can "scarcely be accurately ascertained; but a probable estimate in the case of Tottenham may be "made in the following manner, irrespective of "the original cost of the works:—

	" Per day.		
"Fuel, &c., to lift one million "gallons of Sewage 10 feet "high and drive machinery "for mixing precipitate and "lime........................	0	10	0
"Man to stoke and drive engine	0	3	6
"Two men to sweep tanks and "superintend drying process	0	7	0
"Foreman to pack, send off "manure, and generally "superintend	0	6	0
"35½ cwt. of Phosphate of "Alumina	6	4	3
"17¾ cwt. of Lime	1	15	6
"Oil, tallow, tools, &c.	0	2	0
	£9	8	3

"We find that the cost of three tons of dried "deposit by this process will be, in our case, "£9 8*s* 3*d*, without considering the first outlay "of works, or wear and tear of machinery and "plant"

Remarks on estimates.

17. In this estimate the price at which the lime is put is excessive. Half the amount would be sufficient In many parts of the country lime is to be had at 10*s* the ton; in London and its neighbourhood at 16*s* or 17*s*. The price of it would rarely exceed 20*s*. On the other hand, there is nothing allowed for the 12 cwt. or 14 cwt. of sulphuric or hydrochloric acid which must be employed to dissolve the phosphate of alumina; and at the present moment, other uses having been discovered for this substance, its market value considerably exceeds £3 10*s* per ton. Making due allowance, however, for the errors as respects the lime and acid only, it is manifest that on the estimate of its value by Dr. Voelcker, who is quoted as an authority in its favour, the system cannot produce a manure which will pay for the cost of the process. Mr. Marshall shows that the cost of production (the omission of the acid, the value of which would be about £2 10*s*, would more than compensate for the error in the price of the lime) is over £3 per ton, and Dr. Voelcker reports the value of the manure, as it would be sold in the market, to be less than £2 15*s*.*

Note.—Mr. Marshall states that other samples of the manure obtained from London Sewage had values assigned to them by Dr. Voelcker of £4 10*s* and £7 7*s* per ton. By increasing the quantity of chemicals employed the value of the deposit would of course be greater, but not so in proportion to the cost of production.

Phosphate of Alumina process.

18. Within the last few weeks the fourth of the above-named manure processes has been brought before the public, in which it is intended to use Sulphate of Alumina and Lime as the deodorising and precipitating agents. The plan at present proposed is a modification of the processes of Stothert and Bird, the former of which was shown by the Sewage of Towns Commission (2nd Report) to give results not greatly different from those of the Lime process, the manure from which (par. 5) has already been shown to have very small value as a fertiliser. It has been tried at Coventry on the recommendation of Dr. Anderson. "The tank "contained" (See Dr. Letheby on the Sewage Question) "100,000 gallons of Sewage on each "occasion, and these were treated with 9½ cwt. of "the sulphated material, which, after thorough "agitation, was precipitated with 1¾ cwt. of Lime "previously slacked." Dr. Letheby states that the sulphate is produced by adding 1 part of common Sulphuric Acid to 2 parts of ordinary Clay and then mixing it with its own bulk of water.

Estimated cost and value of deposit.

19. Dr. Anderson says that the total cost of producing one ton of manure by this method is 11*s*; 7*s* 6*d* being for the chemicals and 3*s* 6*d* for labour, &c., and the value of the manure is estimated at 30*s* per ton. It would appear, however, that this estimate is not likely to prove correct in practice, for assuming the data given in pars. 9 & 10 (the conditions will be nearly similar in the two cases) we shall have the cost for

materials in producing 1$\frac{1}{10}$ tons of deposit as follows :—

12 cwt. of Clay at 2*s* 6*d* per ton ...	0	1	6
6 cwt. of Sulphuric Acid at £4 10*s*	1	7	0
4$\frac{1}{3}$ cwt. of Lime at 12*s*	0	2	8
	£1	11	2

or per ton 28*s* 4*d*.

Adding to this Dr. Anderson's estimate for labour, viz., 3*s* 6*d* per ton, and we find that the cost of producing manure by this process, leaving out of account interest on capital, wear and tear, &c., and reckoning materials and labour only, to be almost equal to the *estimated* value of the substance. As we have already seen (par. 10), Messrs. Lawes and Gilbert value the manure obtained by the A B C process at less than 12*s* per ton, and in this process highly fertilising ingredients, as well as those which characterize Dr. Anderson's process, are employed as precipitants. There is therefore some reason to suppose that the manure obtained by the latter method is the least valuable of the two.

Manure processes are failures

20. It appears, then, that the attempt to combine the preparation of an organic manure with the removal of the grosser fecal matters of sewage water can only result in loss of great and uncertain amount. A process which would unite with the use of inexpensive precipitating ingredients the production of a material for which there is something like a steady demand, and which can be produced with certainty, is not to be sought in this direction.

Portland Cement how manufactured.

21. It is, however, to be found in a totally different one. The strongest cement known, the Portland cement, is made by thoroughly incorporating, by mixture with a large body of water, chalk or lime and clay, in the proportion of two parts of *quick-lime* to one part of clay, allowing the compound to settle in large tanks, drying the mixture on hot plates, and then calcining it at a high temperature, and grinding the burnt material to a fine powder.

The components of Portland Cement, good precipitants.

22. Lime is a well known precipitant for sewage water. Clay has likewise been often proposed for a similar purpose, and it certainly exercises a strong decolorising, deodorising and preservative action. The first is an inexpensive substance, very widely met with, and the other is in most localities of a nominal value only. When added to Sewage water they form a precipitate which rapidly subsides, carrying with it all the suspended mineral and organic matters, together with a considerable portion of such matters as exist in the Sewage in a state of solution. The organic matter carried down generally amounts to one-third or one-fourth of the whole, and supplies almost a sufficiency of fuel for the calcination of the lime and clay even to the point at which Portland Cement is produced. It is only necessary to set the dried mixture fairly alight and it will burn freely.

Deposit so obtained innoxious.

23. It might at first be supposed that a precipitate so obtained would have a very nauseous smell, but this is not the case. The deposit after three months is absolutely free from disagreeable

odour, and may be dried, or be made into bricks and stacked for burning, without creating any nuisance at all. Moreover, the process of drying is far less tedious than it is in drying precipitates intended for manures, for nothing need be feared from a rise of temperature which would be sufficient to expel the ammonia, *par excellence* the valuable ingredient as a fertiliser. In cement-making the worst result that could happen from too much heat would be some slight loss of fuel.

Cost of process. 24. To deal with 1,000,000 gallons of ordinary Sewage, the process requires—

For Materials:		
1⅓ tons of Lime at 12*s* ……	0 16 0	
⅔ ,, Clay at 2*s* 6*d* ……	0 1 8	
		0 17 8
For Labour and Fuel:		
Mixing ingredients …………	0 2 6	
Collecting and drying precipitates ……………………	0 12 8	
Burning and grinding, &c. …	0 6 6	
		1 1 8
Cost of Materials and Labour for 2 tons of Cement ………………………………		1 19 4
Value of 2 tons of Cement (wholesale) …		3 0 0
Balance of selling price over cost of production, not including first outlay, wear and tear of plant, &c. …………………		£1 0 8

Note.—This estimate makes no allowance for the increase in the mineral matters of the deposit (lime and clay) derived from the Sewage itself, which we may estimate at more than 20 per cent. It often exceeds 30 per cent.

The process of precipitation and cement-making is now being carried out at Ealing by Mr. T. W. Scott, subject to the supervision of Mr. C. Jones, Engineer to the Local Board.

Chemicals employed to be introduced into Sewers at a distance from depositing tanks.

25. It has been proposed by the inventor of the Cement process, with the view of introducing a more perfect system for the deodorization and precipitation of Sewage matter (see patent obtained by him, and dated 2nd December, 1870), that the chemicals employed shall be introduced into the sewers at a distance from the depositing tanks, and by taking advantage of the running water in the drains, the necessity of mixing machinery be obviated. The joint precipitating action and clarifying effect of the Lime and Clay, or other chemicals employed, is thus promoted to the fullest extent by the natural agitating process to which the mixture is subjected. Moreover, the Sewage matter undergoes purification while flowing through the drains, and thereby the generation of noxious gases, which now find their way into our streets and houses, is prevented. The precipitate formed exercises a scouring action, and the decomposing slimy matter found adhering usually to the bottom and sides of the drains is entirely got rid of, and the Sewage arriving at the outfall is really *fresh* Sewage, which is, as is well known, free from the deleterious influences of that which is undergoing decomposition. Professor Abel states, in reference to this system, that "the various cement-producing ingredients could "scarcely be more thoroughly mixed by the most "efficient mechanical appliances than they are "found to be in the deposit described, which, "therefore, after separation of the water, is at once "in a proper condition for conversion into cement "by simple calcination."

Escape of noxious gases prevented.

The reasonableness of the Cement process.

26. The reasons for the success of the Calcination and Cement process are therefore sufficiently obvious, and its *rationale*, though at first sight surprising, can be readily understood. It clarifies the Sewage by means of inexpensive ingredients, everywhere met with in abundance, which are brought together under the most favourable conditions for the production of a material largely used in the ordinary building trade, and largely exported also to foreign countries and our colonies. The process extracts from the Sewage water additional lime and other mineral matter valuable in cement-making, and leaves an effluent far better suited for irrigation than the original Sewage water, for it increases the quantity of ammonia in it. It also promotes the oxydation of the dissolved organic matter by the slightly alkaline condition imparted to the liquid. It removes from the liquid the whole of the fecal matter which would choke the pores of the soil and injure vegetation. And when the land will bear no more irrigation, it enables the effluent to be dealt with and rendered completely pure by a comparatively small filtering area.

Improves the manurial qualities of the water.

Evidence in favour of Cement process.

27. The following evidence on the Cement system of treating Sewage has lately been given before the Select Committee of the House of Commons on the Birmingham Sewerage Bill. The extracts are from the reports in the Birmingham *Morning News*, *Post*, and *Daily Gazette*.

The President of Civil Engineers.

28. Mr. Thomas Hawksley, President of the Institute of Civil Engineers, said : " It would be

" advantageous, in order to allow the chemical " matter to mix thoroughly, to put the soluble " Salt into the Sewage at the works at Saltley." (Saltley is some miles above the point at Dunton, at which it is proposed to place the depositing tanks) " It was practicable to burn the sludge, " which contained a great deal of combustible " matter ; and the experiment of burning the " sludge had been very successfully carried out by " General Scott." " By adopting General Scott's " process, it (the dried slush) could be converted " into a very useful and valuable cement."

Mr. F. J. Bramwell, C.E.

29. Mr. F. J. Bramwell, C.E., said: "The sludge " deposited at Saltley contains about 15 per cent. " of solid matter, and of that 40 per cent. is combustible, and therefore could be used as fuel. " General Scott's plan of converting the sludge " into cement is very satisfactory, and from what " I have seen of the cement I have the highest " opinion of it." " No injury would be likely to " arise in the way of nuisance from dealing with " the sludge in the manner proposed."

Dr. Odling, F.R.S.

30. Dr. William Odling, Professor of Chemistry at the Royal Institution, said: " I don't think " there is any commercial value in the matter to " be extracted at Dunton, except in its use as " Portland Cement."

Dr. Voelcker, F.R.S.

31. Dr. Augustus Voelcker, Consulting Chemist to the Royal Agricultural Society, said: " I recommend the removal of the sedimentary matter, " or sludge, before the Sewage is used." " Experiments as . to making cement from detritus,

"according to General Scott's plan, are by no "means a nuisance." "The suspended matters in "Sewage are always very offensive, and that is "the reason why populations are so anxious to "get rid of them. If they were allowed to "accumulate they would of course get into a state "of putrefaction, but you can use chemical action "upon them which even when they accumulate "for a certain time—by General Scott's plan "especially—they can be kept free from putrefac- "tion." "In Sewage utilisation one of the essential "conditions is that the water going on to the land "should be as pure as possible."

Dr. Frankland, F.R.S.

32. Dr. Edward Frankland, Professor of Chemistry at the College of Chemistry, and one of the Commissioners for enquiring into the pollution of rivers, said :—"There are various modes of puri- "fying the Sewage, and I should prefer to deal "with the sludge according to General Scott's "system, namely, turning it into cement." "The "process of treatment at Dunton which he would "recommend was to mix Lime and Clay with the "Sewage shortly before it reached the tanks That "would produce a complete deposit in the tanks, "and would deodorize the Sewage, which would "flow on to the land without any smell arising "from it; and the deposit also would be absolutely "inodorous. That deposit would be dried and "converted into Portland Cement."

Professor Abel, F.R.S.

33. The following extracts are from a letter on this subject written by Professor Abel, Chemist to the War Department, from which also the quota-

tion in par. 25 is taken :—" The gain in Lime and " other mineral matters valuable in cement derived " from the Sewage water, the collection from the " Sewage of combustible matter required for the " burning of the deposit into cement, and the " thorough incorporation of the cement-producing " materials without the necessity of mechanical " appliances, must, in my opinion, combine to " render the production of cement through the " agency of Scott's method of Sewage treatment a " profitable business." " It appears to me that, in " addition to the practical value of the process as " a means of readily applying certain portions of " the Sewage constituents to practical purposes, " the method of treating Sewage elaborated by " General Scott possesses some importance from " a sanitary point of view. The effluent water, " while still useful for irrigating purposes, will " have been purified from the most noxious and " dangerous portions of Sewage, and these, although " lost as Manure, will be otherwise profitably " employed, and at the same time completely " destroyed."

Accurate comparison of cost of processes difficult.

34 It is difficult and indeed impossible to make a comparison of the different processes referred to, which will apply generally. The prices of the precipitating materials* vary widely in different

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* The approximate yearly cost of the materials required for the precipitation of the sewage of 100,000 persons would, on the data given, be as follows :—

The Cement process	£900	to	£1,000
The Sulphate of Alumina process	6,000	„	7,000
The A. B. C. „	8,000	„	9,000
The Phosphate of Alumina „	9,000	„	10,000
The Weare's Filtration „	20,000	„	22,000

localities, and the more expensive chemicals fluctuate greatly in their market value. The value of one of them has increased from £3 10*s* to £6 and upwards per ton within the last few months. The Sewage to be operated upon will also cause some variation in the results obtained, and the value of the material produced will be greatly dependent upon position and facilities of transport.

Calcination the best mode of dealing with deposit.

35. Sufficient, however, has been said to justify the title of this pamphlet; and it is evident that, in the minds of those best competent to judge of the question, the Calcination process is the only one that holds out a prospect of commercial success, or even of meeting the expenses of material and labour. It is only necessary to add that Portland Cement is not the only material that can be made by the process. By varying the proportions of the ingredients and the temperature of calcination, according to well-known and easily conducted modifications, Selenitic and other Cements, or Limes valuable for manure, can also be prepared.

NOTE.—Since the foregoing paragraphs were put into type, the Select Committee of the House of Commons on the Birmingham Sewerage Bill have attached to their approval of the purchase of land for filtration the condition that "*no Sewage*" shall "*be put upon any lands without having been previously defecated in tanks.*" Such a decision, arrived at after 14 days' patient hearing of the evidence of the leading authorities in chemistry, engineering and agriculture, makes the question of the dealing with the fecal matters of Sewage of more immediate and paramount importance than ever.

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OPINIONS

OF

EMINENT CHEMISTS AND ENGINEERS

ON

MAJOR-GEN. H. Y. D. SCOTT'S

PROCESSES

FOR

PURIFYING SEWERS

AND PREVENTING

TYPHOID EMANATIONS;

FOR CLARIFYING SEWAGE

AND IMPROVING IRRIGATION,

AND FOR CONVERTING THE DEPOSIT BY

FIRE

INTO

CEMENT.

LONDON:
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1872.

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GENERAL SCOTT'S
SEWAGE CALCINATION
AND
CEMENT PROCESS.

SUNNYSIDE, EALING, LONDON, W.
May 27th, 1872.

SIR,

In reference to my previous communications, dated November 20*th*, 1871, and April 4*th*, 1872, respectively, in reference to General SCOTT'S system of dealing with Sewage, I now beg to submit to you the following evidence in favor of that system, given before the Select Committee of the House of Commons on the Birmingham Sewerage Enquiry Bill.

The Extracts are from the Reports in the "Birmingham Morning News," "Post," and "Daily Gazette":—

Dr. Edward Frankland, F.R.S., Prof^{r.} of Chemistry at the College of Chemistry, and one of the Commissioners for enquiring into the pollution of rivers, said:—"There are various modes of purifying the Sewage, and I should prefer to deal with the sludge according to General Scott's system, namely, turning it into cement." "The process of treatment at Dunton which he would recommend was to mix Lime and Clay with the Sewage shortly before it reached the tanks. That would produce a complete deposit in the tanks, and would deodorize the Sewage, which would flow on to the land without any smell arising from it; and the deposit also would be absolutely inodorous. That deposit would be dried and converted into Portland Cement."

Dr. Augustus Voelcker, F.R.S., Consulting Chemist to the Royal Agricultural Society, said :—" I recommend the removal of the sedimentary matter, or sludge, before the Sewage is used." " Experiments as to making cement from detritus, according to General Scott's plan, are by no means a nuisance. The suspended matters in Sewage are always very offensive, and that is the reason why populations are so anxious to get rid of them. If they were allowed to accumulate they would of course get into a state of putrefaction, but you can use chemical action upon them which even when they accumulate for a certain time—by General Scott's plan especially—they can be kept free from putrefaction. In Sewage utilisation one of the essential conditions is that the water going on to the land should be as pure as possible."

Dr. William Odling, F.R.S., Professor of Chemistry at the Royal Institution, said :—" I don't think there is any commercial value in the matter to be extracted at Dunton, except in its use as Portland Cement."

Mr. Thomas Hawksley, President of the Institute of Civil Engineers, said :—" It would be advantageous, in order to allow the chemical matter to mix thoroughly, to put the soluble Salt into the Sewage at the works at Saltley." (Saltley is some miles above the point at Dunton, at which it is proposed to place the depositing tanks.) " It was practicable to burn the sludge, which contained a great deal of combustible matter; and the experiment of burning the sludge had been very successfully carried out by General Scott." " By adopting General Scott's process, it (the dried slush) could be converted into a very useful and valuable cement."

Mr. F. J. Bramwell, C.E., said :—"The sludge deposited at Saltley contains about 15 per cent. of solid matter, and of that 40 per cent. is combustible, and therefore could be used as fuel. General Scott's plan of converting the sludge into cement is very satisfactory, and from what I have seen of the cement I have the highest opinion of it." "No injury would be likely to arise in the way of nuisance from dealing with the sludge in the manner proposed."

The Select Committee have since attached to their approval of the purchase of land for filtration the condition that "*no Sewage*" shall "*be put upon any lands without having been previously defecated in tanks.*" Such a decision, arrived at after fourteen days' patient hearing of the evidence of the leading authorities in chemistry, engineering and agriculture, makes the question of the dealing with the fecal matters of Sewage of more immediate and paramount importance than ever.

On the 15*th* instant, General Scott read a paper on the same subject before the Society of Arts, Thomas Hawksley, Esq , President of the Institute of Civil Engineers, in the Chair. In the discussion which ensued the following opinions were given :—

Mr. F. A. Abel, F.R.S., said "he had looked carefully into the various points of the process, and was particularly struck by the facility and the completeness with which it could be applied to the clarification and the precipitation of Sewage. The process was at that time carried out certainly in no manner advantageous to its success, but the results which he (Mr. Abel) witnessed were conclusive in his mind, as far as the clarification and precipitation went. Further, he examined several of the products which were obtained by precipitating with a mixture, judiciously proportioned, of lime and clay. He examined them, not merely in regard to their power of being converted regularly into a species of cement, but also with regard to the quality of cement, and he found that it was equal to excellent Portland Cement, or in another case to an excellent hydraulic cement of a different character, produced by another method."

Dr. A. Voelcker, F.R.S., Consulting Chemist to the Royal Agricultural Society, said that "having had an opportunity of visiting the works at Ealing, he wished to bear testimony to the fact that the process of drying and manufacturing the dried material into cement could be carried on in the immediate neighbourhood of the town where the Sewage was obtained without creating the slightest nuisance. The subject brought forward at this meeting in such an able manner by General Scott was one of very great importance, not only to town authorities but also to agriculturists; for he had come to the conclusion that agriculturists would never use Sewage if they had to take it in the foul condition in which it had hitherto been delivered to them. But he was convinced that if Sewage properly clarified were offered to the farmers, they would take it, and would find it a very useful liquid for irrigation purposes." "In all the clarification plans which had hitherto been put in practice, whether they were the Lime, or the Sulphate of Alumina, or the Phosphate Sewage process, very little, comparatively speaking, of the precipitating agents had been used, for obvious reasons—reasons of economy. Now, in General Scott's plan, a very large proportion of earthy matter—Clay and Lime—was used, because the object was to bring out a useful product, and it was mainly due to this circumstance that the Sewage slush did not enter into putrefaction." "A little Lime added to organic refuse matters hastened their decomposition, set up putrefaction, and created a very abominable nuisance. But in General Scott's plan a very large proportion was used, and with this was mixed Clay, a material which possessed remarkable absorbing properties." "The consequence was, that any products of decomposition, which no doubt would be formed, were absorbed and retained by the earthy matter. Be this as it may, it was certainly a fact that the material which was obtained by precipitation according to General Scott's plan, could be kept in a wet and pasty condition for two or three months. He had himself examined at Ealing some of the clay and lime sewage mud which had been kept for nearly three months, and he found it had no disagreeable smell." "This led him to the third point, on which he would just offer a remark which perhaps might not have occurred to General Scott. It was this—that the material from which he made cement might be dried in the open air without creating a nuisance. Indeed, he believed it would be found in practice that air-drying would be the most economical and probably the most efficacious plan of producing a material which could be burnt in a cement-kiln. There was a large quantity of earthy matter mixed up with the material which formed the sewage slush, and the consequence was that it got penetrated by air and dried itself; whereas one of the most difficult things in the world was to dry the deposit obtained by simple subsidence of the sewage slush obtained by the mixture of a small quantity of lime or sulphate of alumina. He knew of no substance which it was so difficult to dry, and, consequently, which it was so expensive to dry, as sewage slush; but by General Scott's plan, the deposit, being mixed with much earthy matter, was at once rendered porous, so that by exposure to air it dried itself, and this was a matter of very great importance, for although, no doubt, sewage slush could be dried artificially and burnt, yet there was a great objection to this artificial drying in the expense which had to be incurred. The simple evaporation of the water was by no means a guide as to the expense. These were some of the points which had forcibly struck him as being in favour of General Scott's plan."

Mr. Rawlinson, C.B., said "the mixture of lime and clay was put in such proportions as were requisite to produce the qualities of hydraulic cement." "If that could be successfully accomplished, he did not think it was a pounds, shillings and pence question exactly. There was no process with which he was acquainted by which towns could treat their Sewage so that it should be a profitable concern if they had to get rid of it without the means of putting it, by irrigation, to the land. The towns produced the Sewage; it was a nuisance to the community, and it was necessary to the health of the community to dispose of it, and they must be contented to pay, by a rate in aid, for getting rid of that which was no benefit to them, and which, in its grosser form as discharged from towns, was an injury to the country. The sooner that was understood, and put on all fours, the better it would be for everybody."

Mr. W. Hope, V.C., said "he had listened with very great pleasure to the paper of General Scott, who had made a very original, and he hoped useful discovery. The sludge was always a great difficulty in dealing with Sewage, no matter by what process or theory."

Mr. Lloyd, Member of the Metropolitan Board, said "the Metropolitan Board were perfectly free and unfettered in any way with regard to the A B C system or any other system of Sewage, and were prepared to treat with that which could be shown to be the best for the benefit of the metropolis. He thought it necessary and fair to make that statement. It appeared to him that there were two great problems to be solved. The first was so to clear Sewage of its impurities that they might be able to turn it into water-courses which carried off the effluent water. It must be so little deleterious that the water-courses would not be injured by it. And the next great problem was, whether the result or residue, if diverted from the water-courses, could be made a source of profit, so as to return something for the benefit of the ratepayers who had paid for carrying off the Sewage. Those were the two great problems which ought to be set before scientific men; and when they had dealt with both in a satisfactory way, the Metropolitan Board and other nuisance authorities in the kingdom would only be too glad to step in and give aid."

Mr F. J. Bramwell, C.E., said "he did not know that he had much to add to what had been already said upon this subject, except to draw attention to something which General Scott appeared to have omitted from his paper, but which he had communicated to him (Mr. Bramwell) when he had the pleasure of seeing the process at Ealing. He would say a word first of all in reference to an observation of Mr. White, although perhaps it would be doing what Mr. White had asked General Scott to do, viz., to answer a question. Mr. White put it, 'Does the water contain lime, and does the water contain clay?' Now he supposed most Sewage contained lime, but if it did not, it contained something which everybody was desirous of getting rid of, and that was the gluey, sticky, filthy sludge. That was a thing which everybody had decided ought to be got rid of before the water should go into any channel. That being so, supposing it contained no ingredient whatever to make Portland Cement, but supposing that the materials to cause it to become inoffensive were such materials as made Portland Cement, then you put those in, not because you wanted to make Portland Cement, but because you wanted to make the sludge harmless and inoffensive; and if you could afterwards make Portland Cement, why should not you do so? That he understood to be General Scott's proposition. As the object was simply to do that which he had stated, to get these matters deposited and the nuisance removed, there was a temptation, if they could not utilise the material resulting, to diminish the quantity put in, and thus the Lime process, as Professor Voelcker said, had got into disrepute in a variety of places because it was endeavoured to be carried out at the least possible cost. But if they could, as General Scott had pointed out, get a saleable result, then the temptation diminished, and they got an entire deodorisation." "With respect to the detritus, as Mr. Rawlinson had observed, that came down so rapidly when the settling tank was reached that it came out in the very first compartment, and therefore the fear in Mr. White's mind (that by no possibility could you get the ingredients you wanted because detritus was mixed with them) had no foundation, and we did, in truth, get the sludge unmixed."

Mr. Chas. Jones, C.E., Eng$^{r.}$ to Ealing Local Board, said "he had closely watched the system for the past six months, and found not the slightest inconvenience from the presence of the deposit. He had seen material turned out by the process which he should pass as first-class cement without the slightest hesitation." "The question of cleaning the sewers was a most important one, and the process certainly had a very salutary effect in getting rid of the sewer gases; he could now pass through his main sewer without the slightest inconvenience from them." "He (Mr. Jones) believed that in a place with a population of 20,000 persons, double that of Ealing, the scheme would absolutely pay, and that was an important feature in connection with the subject. He had tried experiments with various systems during the last eight or nine years, but he had seen none which had succeeded so well as that which General Scott had introduced."

Dr. Odling, F.R.S., said "that he had seen General Scott's process carried out at Ealing, and he must say that he was very much impressed with it. It appeared to him that whatever might be the ultimate disposal of Sewage, there must be a large number of cases in which it would be desirable to separate the sludge from the liquid matter, and the manner of separating the sludge adopted by General Scott was certainly most complete. Then remained the question in what manner or for what purpose this sludge should be disposed of; and in dealing with that question General Scott had struck out a new line of work. He had availed himself of what Mr. Bramwell had called the 'fuel' in the material, and he had availed himself of its other most valuable constituents, and he had recovered the material with which he effected the process in a form more valuable than it was before it was used. Economically, the scheme seemed to him the most promising of all which had been introduced for the purpose of dealing with Sewage, and throwing down the sludge from it, and then dealing with the solid portion so as to convert it into a useful marketable article."

Mr. P. P. Marshall, A.I.C.E., Engineer to the Local Board at Tottenham, said "irrigation was no doubt one of the best modes of dealing with Sewage, but the plants ought not to be forced with it. An excess of it produced a black mark on the stalk of the plant, which took three weeks to clear away. He thought that a combination of General Scott's process with irrigation might be a solution of the difficulty."

Mr. R. Grantham said "he had had the means of watching General Scott's process a little. He had sent an inspector from the Committee of the British Association, and they had a favourable account and report of it. At present there was not a good opportunity for making experiments, and he proposed that a further investigation should be gone into. General Scott had given every facility for making experiments. He looked upon it as a very great improvement and advantage if they could get rid of the sludge in some way or other, by drying processes, or by any other means which could be devised. General Scott's plan, as far as he was aware, was certainly the best, and he really hoped that it would prove successful, and be adopted in many parts of the country."

Dr. Letheby said that, "in common with all who took any interest whatever in this question, he had had a good deal of satisfaction in listening to the paper read by General Scott, not merely because it seemed to offer a practical means of solving a great difficulty, but chiefly because it seemed to him to be the means whereby people of the most opposite inventions, and theories, and practices, might be brought somewhat into harmony. On the one hand, those who were advocates of the precipitating process would find in it the means of carrying out all they wished; and, on the other hand, those who were particularly anxious for the use of the Sewage water or effluent water upon the land, would find an opportunity of using it advantageously." "One other point had struck him during the reading of the paper and the discussion which had arisen out of it, and that was as to the quantity of Cement that would possibly be produced from a given quantity of Sewage. Now, looking at the experience which we had during the days of the old Tottenham works and of the works also at Leicester, it was found in practice that the proportion of solid matter that was obtained was invariably between four and five times that of the Lime used. He calculated, therefore, that two tons and a half of this Cement would be obtained from a million gallons of Sewage. That would be about a ton for every 10,000 people per day. Well, he did not know what might be the demand for Cement, but it did not strike him at first sight as being a very large quantity. Such a quantity might very well be used in building operations." "He had listened with very great satisfaction to the account of the process, and he fancied and hoped that he saw in it a means by which we should get out of the great difficulty which pressed upon all the towns of England, namely, the economical disposal of the soil."

If you wish to have further information on the subject, I shall be happy to send you a pamphlet entering at some length into a comparison of this with other processes.

I am, Sir,
Yours obediently,
THOMAS W. SCOTT.

With the Author's compliments

THE WATER SUPPLY OF TÔKIÔ,

BY

R. W. ATKINSON, B.Sc.,

Professor of Applied Chemistry in the University of Tôkiô.

Read before the Asiatic Society of Japan,
on the 24th November, 1877.

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It is universally admitted that the water supply of a large town is a matter of the greatest importance to the health and well-being of the community, and it is a subject at the present time occupying the attention of those who are in any way responsible for the good health of the people, and of the people themselves. Experience has proved that many diseases have originated from a contaminated water supply, and though there may be differences of opinion regarding the nature of the action of the water, there are none concerning the fact itself. Instance could be added to instance of cases where a well having become infected in some way, the particular disease has been communicated to all who have drunk of the water. The majority of those who are competent to give an opinion upon the nature of the source of such diseases agree that they are due to the presence of minute organisms, too small to be seen even under the highest powers of the microscope, but capable of becoming developed and of reproducing their kind. The wonderful and rapid spreading of such diseases is one of the strongest arguments in favour of the germ theory of infection, and it is difficult to understand the rapidity of the growth of such diseases unless we compare it with the known rapidity of the development of some of the lower forms of animals and plants. If this be the case it is of the utmost necessity to preserve the water used for drinking purposes perfectly free from contamination with any suspicious matter; and this would appear reasonable so long as there is even a doubt upon the subject. But experience speaks for itself, for in those towns in which the purest water is supplied, epidemics are either unknown or are felt with very much less intensity. Thus it is stated that in Glasgow during the three epidemics of 1832, 1849 and 1854, when the source of the water supply was the polluted river Clyde, the average mortality from cholera was 121·6 per 10,000 people, while in 1866 after the city had been supplied with Loch Katrine water, the mortality was only 1·6 per 10,000 of population. The epidemic which broke out in the village of Lausen, near Bâsle, Switzerland, in 1872, has proved that infected water may traverse a distance of more than a mile through earth without losing its power of causing disease. And this is not to be wondered at if we consider the germs of disease to be the eggs of low forms of animals or the spores of certain plants, whereas, if they consisted of organic, but not living substances, the probability is that they would be completely oxidized. Dr. Frankland, in a paper read before the Chemical Society, London, in 1868, gave a very striking illustration of this, which will best be given in his own words. "If the shell of an egg were broken and its contents beaten up with the water and thrown into the Thames at Oxford, the albumen would probably be entirely converted into mineral compounds before it reached Teddington; but no such destruction of the nitrogenous organic matter would ensue if the egg were carried down the stream unbroken for the same distance, the egg would even retain its vitality under circumstances which would break up and destroy dead or unorganized organic matter. Now, excrementitious matters certainly sometimes, if not always, contain the germs or ova of organized beings; and as many of these can doubtless retain their vitality for a long time in water, it follows that they can resist the oxidizing influences which destroy the excrementitious matter associated with them." The legitimate deduction from this is that a water to which infected matter has at any time gained access should be rejected for drinking purposes, no matter how much it may subsequently have been exposed to the air. How is it to be known whether a water is contaminated or not? No means are known at present of stating positively whether a water contains the germs of disease without physiological experiments which are undesirable, but from the constant association of germs with excrementitious matter we have a means of knowing whether a water is dangerous or not. Any water which can be proved to have previously been charged with sewage, ought to be rejected whether organic matter be present to any large extent or not at the time of examination. Chemical analysis supplies the means of knowing the previous history of the water, and though it will not say whether a water is disease-infected or not, it gives us the means of ascertaining whether a water is pure and undefiled or dangerous. For sanitary purposes it is not necessary to know the nature and amount of all the constituents of a water, but it is necessary to have some means of knowing the amount, relative or absolute, of fresh organic matter, as well as the amount of those mineral substances which result from the oxidation of organic matter. Excrementitious organic matter contains carbon, hydrogen, oxygen, and nitrogen and the products of its oxidization and change are water, carbonic acid, ammonia, and nitric and nitrous acids. Of these the only bodies available for the purpose of analysis are ammonia, nitric and nitrous acids. If we find considerable quantities of these substances in any natural water we know certainly that they have been derived from sewage matter. It must, however, be remembered that rain water always contains small quantities of these bodies, and therefore in estimating the value of a water, the average amount present in rain water has to be deducted from the amount found in the water under examination. Chemical analysis can also show the relative amount of present organic matter in different waters, and this is a point of great importance, for it shows how recent has been the contamination with sewage matter.

The accompanying tables give the results of analyses made in the Chemical Laboratory of the University of Tôkiô by Messrs. Ishimatsu, Takamatsu, and Takayama, senior students, under my direction. The sample of water from the districts supplied by the Kanda were collected on the same day, except the two first, and those from the district supplied by the Tama water were also collected on one day. The specimens of surface waters were collected on different days.

It will be convenient here to explain the meaning of the numbers given in the various columns.

1. *Solids:*—Obtained by evaporating 100 cubic centimetres of the water to dryness over the water-bath, great care being taken to guard against the admission of any particles of dust, and drying at 110° C. This includes besides mineral matter, such organic matter as has not been expelled during the evaporation.

2. *Chlorine:*—Estimated by means of a standard solution of argentic nitrate. The presence of chlorine is partly owing to spray which is blown by the winds from the bay of Yedo into the interior, and when in large quantity, may indicate contamination with sewage. Its determination is very important.

3. *Free Ammonia:*—Determined by distillation and estimation in the distillate by means of Nessler's re-agent. All rain water contains free ammonia, but only in small quantities; when present in large amount in water it usually indicates the presence of decomposing urea, and so points to sewage contamination. The presence of a considerable amount of chlorine in a water, together with a large amount of ammonia, will usually be sufficient to condemn that water on account of recent contact with sewage.

4. *Albumenoid Ammonia:*—Is determined by boiling with an alkaline solution of potassic permanganate, and

estimating the ammonia in the distillate as in (3). All nitrogenous substances do not give off the whole of their nitrogen as ammonia, but that is a matter of little moment, since all that is required is to get comparative results. Urea, although giving off no ammonia when treated as above, is recognised with certainty by the presence of chlorine with which it is always associated in sewage. Although, therefore, the numbers obtained in this determination do not represent the whole of the nitrogen contained in the organic substances present in the water, yet when it is found that one water yields a large quantity of ammonia whilst another water yields only a small quantity, when treated with alkaline permanganate the inference is justly drawn that the former contains a larger quantity of nitrogenous organic matter than the latter. Before making this determination the free ammonia is, of course, expelled.

5.—*Oxidized Nitrogen:* Determined by first expelling the free ammonia present and treating the residual water with caustic potash and powdered zinc. The nitrates and nitrites are reduced to ammonia, and the amount of ammonia liberated is ascertained as before.

When an organic substance containing nitrogen is exposed to slow oxidation, especially in presence of basic substances, the nitrogen forms nitrous and nitric acids, and thus the determination of the nitrogen existing in a water in this form is a measure of the amount of nitrogenous organic matter which has previously been contained in the water and has undergone oxidation. In some cases it may be derived from soil containing animal organic matter in a state of oxidation, through which the water has passed, but in either case it tells the past history of the water. Although the presence of nitrates and nitrites in a water is not of itself injurious, it is a sign that the water has passed through conditions which might permit it to become infected with the germs of disease, and therefore when found in any quantity in water, such water ought not to be used for drinking purposes at any time, but especial care should be taken during the prevalence of an epidemic. At such times it is the duty of an enlightened government to forbid the use of such water, and to supply the district with pure water at the public expense.

6.—*Total Mineral Nitrogen:* By this is meant the amount of nitrogen existing in the water after deducting that contained in average rain water, in the form of ammonia and oxidized nitrogen. It does not include the "albumenoid ammonia." It, therefore, expresses the amount of that element which has been taken up by the water in passing through impure soil, or by having come into contact in some other way with animal excreta. This number, therefore, expresses the actual amount of contamination with which the water at one time or another has been in contact. Dr. Frankland, in his reports on the water supplied by the eight London water Companies made for the Registrar General, has introduced the term "Previous Sewage Contamination" to express the quality of a drinking water, and this number will be found in column

7.—It is calculated in the following way :—Taking the amount of combined nitrogen in 1,000,000 parts of rain water as =0.32 parts, this number is deducted from the sum of the nitrogen present in the form of free ammonia and oxidized nitrogen. Then, as average filtered London sewage has been found to contain 100 parts of combined nitrogen in 1,000,000 parts, (=1 in 10,000 parts) we can express the amount of sewage with which the water has been in contact by the following formula—$10{,}000\ (N + N^1 - r)$, when N expresses the amount of nitrogen existing in the form of ammonia, and N^1 that present in the oxidized state, and r is the total amount of combined nitrogen in rain water.

It will be understood from what has been said under the head of oxidized nitrogen, that this number does not express the amount of organic matter actually present in the water, but only that which has been completely oxidized, and as there are many causes which lead to a removal of the nitrates and nitrites from a water, such as the presence of growing plants, etc., the number so obtained can only be regarded as the minimum amount of impurity.

In order to form an opinion as to the amount of present impurity, we must look to the column headed albumenoid ammonia, and the number there given will show whether the contamination is recent or old.

8.—*Calcium Salts.* This indicates the amount of carbonate of calcium or other soap destroying salts contained in the water.

Tôkiô is supplied with water from three different sources. The city proper, that is the part bounded by the Sumidagawa and the bay of Yedo on the one side, and by a line extending from Kanasugi-bashi, Shiba, to Toranomon, thence by the outer moat of the castle and, the Kandagawa as far as Riogoku-bashi, is supplied by means of pipes which bring water from two sources, and, except in the elevated districts of Bancho and Suruga-dai, surface water is not used. The rest of Tôkiô outside the castle walls, and the districts of Honjo* and Fukugawa on the other side of the river, use only surface water. The two kinds of water which are distributed to the different parts of the city are derived from the Tamagawa, and from the Kanda. The point at which the water is taken off from the Tamagawa is about 12 *ri* from Tôkiô, and water is conveyed to the city in an open canal to Yotsuya, where it enters the city pipe and discharges at Reiganjima. It supplies the whole of the city south of a line drawn from Yotsuya to Hitotsu-bashi, from this to Wadagura-go-mon thence to Kaji-bashi, and from this to O-hashi, following the canal north of Hachobori and Reiganjima.

The source of the Kanda water is about 4 *ri* from the Dai Gaku, and consists of three ponds, but a branch canal of the Tamagawa joins it on the way, so that the two waters are mixed in about equal quantities. It enters the city pipe at Sekiguchi, Koishikawa, and discharges at Riogoku-bashi and Kio-bashi. The remainder of the city, with the exception of Bancho and Surugadai, which use surface water, are supplied with Kanda water. I am indebted to Mr. Matsumoto, Engineer to the Tokio *Fu,* for the above particulars, and also for information respecting the best points from which to take samples of the water of the two supplies.

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* Honjo is to some extent supplied with Tamagawa water brought over in boats from Reiganjima.

Tamagawa Water. (Table I) :—The water from Kojimachi may be considered as the raw material which is used to supply the district, and from the results of analysis it will be seen to be of good quality and well fitted to supply the wants of a large town. Although it is not absolutely pure, the amount of impurity is so small that it proves the previous contact with sewage to have been of very slight extent. And the quality of the waters taken from Toranomon, Kanasugi-bashi (Shiba), and Hachobori approach it in purity, though the former appears to have been slightly contaminated by some local impurity. The two remaining specimens of this water, however, taken from Tsukiji and Reiganjima contain very considerable amounts of impurity, as is indicated by the large amount of chlorine and free ammonia. The chlorine is probably derived in part from the water of the bay, but that the increase is not wholly due to this circumstance, is shown by the presence of a large amount of ammonia, which can only have been derived from the decomposition of animal matter. In these low lying districts where the flow of the water is smaller, there must be a much greater tendency for impurities to leak in through the joints of the pipes than in the higher districts, and in this way the greater amount of impurity may be accounted for. But, the pipes being made of wood, in time become saturated with water and a process of diffusion must occur between the water in the pipe and the impure liquids outside. This diffusion will take place throughout the whole system of pipes, but will be much more marked in those districts towards the end of the supply where the flow is more sluggish.

Kanda Water. (Table II) :—The specimens taken at different points of the district supplied from this source show a progressive increase of impurity as the distance from the source is greater. At Sekiguchi (Koishikawa) where it first enters the city pipes, it equals in purity the water derived from the Tamagawa, and if its purity could be

TABLE I—TAMAGAWA WATER, TOKIO.

Sample of water taken from	PARTS IN 1,000,000 of Water.							
	Solids.	Chlorine.	Ammonia.		Oxidized Nitrogen.	Total Mineral Nitrogen.	Previous sewage contamination.	Calcium Salts.
			Free.	Albumenoid				
Koji-machi, 5-chôme	60·5	6 5	028	·036	·888	·596	5960	44
Kotahira-chô, (Tora-no-mon), No. 1.	87·5	11·5	·106	·043	1·185	·971	9710	51
Hamamatsu-chô, (Shiba), No. 1	69·5	7·0	·049	·069	·954	·683	6830	39
Odawara-chô, (Tsukidji), 3-chôme, No. 7	160·5	23·0	2·476	·065	·959	3·115	31150	57
Matsuya-chô, (Hon Hachôbori), 3-chôme, No. 2.	106·5	10·5	·068	·047	·567	·315	3150	49
Shio-chô, (Reiganjima) No. 4	261·5	43·5	1·079	·070	1·911	2·68	26800	82·5

TABLE II.—KANDA WATER, TOKIO.

Sample of water taken from	PARTS IN 1,000,000 OF WATER.							
	Solids.	Chlorine.	Ammonia.		Oxidized Nitrogen.	Total Mineral Nitrogen.	Previous sewage contamination.	Calcium Salts.
			Free.	Albumenoid.				
Sekiguchi (Koishi-kawa), open canal.	98	7·9	·055	·121	·81	·545	5450	48
Sarugaku-chô, 3-chôme, No. 3	110	9·5	·071	·129	1·07	·821	8210	51
Hon-chô, 3-chôme, No. 2	87	15·5	·205	·121	·98	·865	8650	49
Tori Abura-chô, No. 11	144·5	25·5	·422	·159	1·44	1·542	15420	77
Minami Temma-chô (Kio-bashi), 3-chôme, No. 5	203·5	30·5	·551	·185	1·09	1·321	13210	83·5
Koami-chô, 3-chôme, No. 26	250	33·5	·505	·187	1·72	1·905	19050	88·5
Kakigara-chô, 3-chôme, No. 10	240·5	42·0	1·630	1·650	1·65	2·96	29600	78
Yonezawa-chô (Riogoku-bashi), 3-chôme, No. 5	287·5	49·5	4·29	·245	1·17	5·14	51400	90

TABLE III.—SURFACE WATERS, TOKIO.

Sample of water taken from	Depth in feet.	PARTS IN 1,000,000 OF WATER.							
		Solids.	Chlorine.	AMMONIA.		Oxidized Nitrogen.	Total Mineral Nitrogen.	Previous sewage contamination.	Calcium Salts.
				Free.	Albumenoid.				
Koishi-kawa, Kanatomi-chô, No. 22.. (From A. Hamao, Esq)	24	347·5	4·1	·04	·065	4·755	4·475	44750	76·5
Ichiban-chô, No. 49.................... (From K. Fukuda, Esq.)	30	435	83·0	·026	·064	7·204	6·910	69100	131·0
Suruga-dai, Nisshi Kôbai-chô, No. 12. (From Prof. Jewett.)	45	750	126·7	·118	·093	33·356	33·154	331540	141
Kaga yashiki Hospital, Hongô......	38	217·5	37·0	·025	·031	3·62	3·325	33250	54
Asakusa, Kita Kiyoji-machi, No. 15...	8⅓	411·5	54·5	·076	·031	6·245	6·001	60010	115
Mukôjima, Komme-mura, No. 64... (From H. Wurin, Esq.)	3	193.5	5·5	·024	·073	1·208	·912	9120	22
Honjo, Koidzumi-chô, No. 22.........	9	307·5	37·5	·645	·175	1·026	1·351	13510	71·5
Fukagawa, Ishizaki-chô, No. 32......	10½	595·5	220·5	·439	·333	1·166	1·285	12850	85·5

TABLE IV.—EXAMPLES OF OTHER DRINKING WATERS FOR COMPARISON.

Name of water.	PARTS IN 1,000,000 OF WATER.							
	Solids.	Chlorine.	AMMONIA.		Oxidized Nitrogen.	Total Mineral Nitrogen.	Previous sewage contamination.	Calcium Salts.
			Free.	Albumenoid.				
Thames Water as delivered in London	309·4	17	·015	·105	3·46	3·155	31550	—
New River Co.'s Water...............	302	15·7	·012	·070	3·61	3·302	33020	—
East London Co..................... ...	360	—	·017	·103	3·07	2·767	27670	—
Kent Co..	448	—	·01	·02	4·08	3·770	37700	—
Glasgow Water..............................	32·8	7·6	·00	·08	·31	·00	0	—
Manchester Water	68	9	·01	·06	·01	·00	0	—
Well water near Preston, Lancashire.	544	—	·03	—	24·66	24·36	243600	—

preserved, no exception could be taken to the water supplied to the city of Tôkiô.

But the results of analysis show that this is not the case. It is very interesting to observe how nearly regular the increase is, starting from Koishikawa. The three first samples are very pure, containing small amounts only of solid matter, chlorine, ammonia and oxidized nitrogen, whilst those samples taken from the centre of the populous district supplied with this water present much larger quantities of each of these constituents. The two last specimens taken from near the end of the supply, at Kakigara-chô, and Yonezawa-chô (Riogoku-bashi), have evidently been very largely contaminated with organic matter, the amount of albumenoid ammonia being very large, whilst the evidence of previous pollution is also very strong. This comparison of these various waters, therefore, confirms the remarks made in connection with the Tamagawa water. It is quite evident that the use of wooden pipes is not sufficient to preserve the quality of the water, and as such pipes are proved capable of admitting organic contamination into the water supply, there is no reason to suppose that they will exert any special exclusive action on the disease germs which may surround them. Imagine a few isolated cases of any zymotic disease breaking out in any part of this thickly inhabited district, and consider how impossible it is to prevent some of the excreta of such patients finding its way into the soil and so into the water supply, and it will be evident that such germs will spread like wildfire through the whole of the district supplied subsequently by such water. In such a case the water, indeed, acts as a carrier of the disease, and its use is even worse than that of the water from surface wells, which at most supply only a few houses. The natural inference to be drawn from these analyses is that, the water being good to start with, proper means should be taken to preserve its purity by the adoption of some system which will prevent the introduction of impurity from the soil, that is, by replacing the wooden pipes by others made of some impervious material.

Table IV. is given, compiled from the results published by Dr. Frankland in his paper read before the Chemical Society in 1869, and from analyses given by Professor Wanklyn in his treatise on water analysis, in order that a comparison may be instituted between the water used in Tôkiô and that supplied to London, and some other places in England. It will be seen that the Tôkiô water at its source is greatly superior to any of the London waters, but that it is inferior to the water supplied to Manchester and Glasgow. The London supply is, however, confessedly imperfect, and agitation is at the present time being made for its replacement by water from some purer source. The waters of Manchester and Glasgow are extremely pure, being derived from uncontaminated sources and not being permitted to come near any impurity. The character of these waters, also, is preserved by their being transmitted through impervious pipes, and thus the water taken from every part of the system will have the same composition.

Surface Waters:—(Table III). It is, however, in the surface water that we may expect to find the largest amount of impurity, for, from its origin it passes through soil charged with all sorts of organic matter, and collects in some basin, from which it is obtained by wells sunk through the earth till they reach the level of the water. It will be obvious that the deeper the water sinks the greater will be the amount of impurity taken up by it, other conditions remaining the same, and this is for the most part borne out by the examinations made of the surface water from different parts of Tôkiô. In all except that from Mukojima the number expressing the "previous sewage contamination" is very high, while the amount of "albumenoid ammonia" is comparatively small, not greater than that found in most specimens of London water, except in the waters from Honjo and Fukagawa. The use of the latter water was, I believe, condemned by the Tôkiô *Fu*, during the prevalence of cholera in that district, but without actually closing the wells it would be difficult to ensue perfect obedience to such an order.

The result of the analysis of these two waters shows that there existed good reasons for closing the wells of the districts, the amount of organic matter actually present being quite abnormal. The large quantity of chlorine contained in the water from Fukugawa may have been derived from contact with sea water, but the presence of ammonia and the large amount of solid residue suffice to condemn its use for drinking purposes. It will, also, be noticed here that the numbers expressing the "previous pollution" of the last two waters are comparatively small, showing that the contamination is of more recent date than that of the other wells, the time which has elapsed since the pollution, not having been sufficient to effect the oxidation of the nitrogenous animal matter.

The purest of these surface waters is, undoubtedly, that from Mukojima, which shows very little more impurity than is contained in the Tamagawa or Kanda waters at their sources. The water is obtained here by digging a hole into the ground and sinking a bamboo pipe, when the water rises to within a short distance from the ground. It is thus a species of Artesian well, and as its resevoir is probably situated some considerable distance below the surface, to which sewage has less opportunity of gaining access, its high degree of purity is explained.

The most impure water I have examined is that collected from Surugadai, and as the results were so extraordinary, a second sample from the same well was taken about ten days after the first sample, and analyzed with similar results. There seems to be no doubt, therefore, that the results obtained express the ordinary quality of the water used in this part. The water was 45 feet below the level of the ground, and the resevoir would thus seem to be nearly at the same level as the Kandu-gawa.* On account of its great depth and from the populous character of the neighbourhood, it is reasonable to suppose that it receives the drainings from all the houses on the hill, and in this way its unwholesomeness would be fully accounted for. It is scarcely necessary to say that its continued use as a drinking water is exceedingly dangerous, and it should be replaced by the purer Kanda† water which is within easy reach.

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* The depth of the water in wells in various parts of Suruga-dai was measured, and it was found that, roughly, the depth was greatest at the highest points of the hill, affording probable evidence that the whole hill is supplied with the same water.

I regret that there has been no opportunity of examining samples of surface waters from a greater number of localities, but they would probably nearly all show similar characters. The results of these analyses may be thus expressed :—

1°.—The waters supplied to the city are originally good, but become deteriorated by passage through wooden pipes.

2°.—Most of the surface waters are dangerous, and some are exceptionally bad.

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† It most be borne in mind that the Kanda which supplies the drinking water differs from the Kanda-gawa.

ASIATIC SOCIETY OF JAPAN.

A General Meeting of the Asiatic Society was held at the Tôkiô Dai-gaku on Saturday, 24th November, Sir Harry S. Parkes, President in the chair.

The minutes of the previous meeting were taken as read.

Mr. Ayrton announced on behalf of the Council, that it had been proposed to alter rule 25, by which it was provided that 10 copies of a paper should be given to the author, and in accordance with standing regulations Dr. Divers, Mr. Chaplin and Dr. Faulds were appointed a committee to confer with the Council on that subject. The election of the following gentlemen as new members was then announced, Dr. Divers; Mr. Terry; Captain James.

Dr. Faulds remarked that since his note at the last meeting on the waxy bodies which he considered to be the undeveloped female of an aphis, he had discovered a winged aphis which was very probably the sought-for male.

Mr. Atkinson then read a paper upon the "Water Supply of Tôkiô."

At its conclusion Mr. Chaplin said:—That the paper which had been read was of great interest to the people of Tôkiô just at this time; and it was valuable to engineers the world over, because it showed that wooden pipes were unsafe to carry water for domestic purposes. It had been known for a long time that metal pipes were liable to injure the water running through them; but this was the first investigation, which he had seen, which seemed to prove that wooden pipes had the same failing. He did not think it probable that there was any flow of contaminated water into the pipes through leaks; because the pipes were carefully made and generally the head of the water inside the pipes was greater than the head of the water outside. The water works of Tôkiô were, on many accounts, remarkable. When they were built, they were probably the most extensive works in the world. The first works for supplying the people of Tôkiô with water were made to carry water from a hill near Akasaka to a section which had been formed by filling in a marsh on the shore of the bay; probably this was the place now called Tsukiji. When these works were built the city was very different from the present city. Old maps show Asakusa as a separate village and the place where the Tôkiô Dai-gaku is, as a marsh. As the city extended, the supply of water was obtained from other streams flowing through the city, but all these works had now disappeared. The Kanda water-works were probably built about 1650. They were supplied by three small ponds which lie west of the city. These ponds were shallow and nearly filled with water-plants. The people living near them said they were supplied by springs, and that the water was generally cold in summer. The greater part of the water in the Kanda water-works came from a canal which connected them with the Tama canals. The Tama water-works were built in 1653. They brought the water from the Tama river at a point where that river left the hills. At this place the water seemed to be very pure and there was an abundance of it. In mid-summer the canal took nearly all the apparent flow of the river, but, as the bed was formed of washed gravel, and as there were always pools of clear water below the dam, it was probable that a large part of the water ran below the top of the gravel. At this point, Hamura, there was a low dam across the river, and the banks were protected in such a way as to show that during high water the river was a very powerful stream. The canal was almost wholly in excavation,—in fact there was but one embankment, which was near the limits of Tôkiô. At one place the canal ran through a slight depression in the surface of the plain, and the water now filled this. When the canal was built it was believed that the cherry tree had the power of abstracting poison from water; so, many trees were planted around this artificial lake. These trees were still standing. All along the canal were villages which drew their supply of water from the canal, and in many places were side canals which drive flour mills. It had been found that in summer 150,000,000 gallons of water left Hamura daily; but of this quantity only about one-eighth entered Tôkiô through the Tama water-works. How much came through the Kanda water-works, he did not know; probably as much more. Considering the fact that when these canals were made the Japanese had no shovels or carts, in fact none of the tools of the modern navvy, and that all the earth had to be carried out of the canal either in baskets or on mats, their construction must certainly be considered wonderful. A rough calculation showed that more earth was moved in building them than in building the railroad from Tôkiô to Yokohama. The records showed that the cost of building the Tama water canal was only 9,000 *yen*, of which the Shôgun paid 8,000 and the engineers raised 1,000. The cost per cubic yard must have been less than one *sen*, or about a twentieth of what it would cost now. The engineers of the Tama canal were two head men of the village of Hamura. They received as a reward a pension of 200 *koku* of rice. In the city the water was distributed through wooden pipes. The large pipes were made of several planks, two and a half or three inches thick, spiked together. The small ones were made of square timbers, which were hollowed out so as to form three sides of the pipes, and on these planks were nailed to form the fourth side. All the joints were caulked with cedar bark. The water was not carried into the houses but ran into wells. Honjo was supplied with water by boats, which obtained it from the pipes in the other parts of the city and from the rivers at points above tide-water. The cost per gallon was about one *rin*.

The length of the Tama canal from Hamura to Toranomon was 28.9 miles; of the Kanda canal 14 miles. Connected with the Tama canal were 30.3 miles of pipes and with the

Kanda canal were 29.1 miles. These pipes supply 8,000 wells. The engineer of the Tôkiê *Fu* had designed works in modern style to supply, not only the parts which were now supplied, but also the parts lying beyond the Sumida river and south of the castle. He proposed building reservoirs in the city and raising water to the high points by steam power. The city was spread over so much ground that the cost must be unusually large. Mr. Atkinson's paper showed the necessity of improving and extending the present system, and, if no other plan was possible, it was doubtless the duty of the authorities to go to the great expense of carrying out the engineer's plan.

Dr. Faulds said he had to express his thanks for Mr. Atkinson's valuable researches, the accuracy of which on some points he believed he was able to confirm from observations made in another field of study and by quite different methods. He had shown that in Odawara-chê and in Suruga-dai districts the water was exceptionally impure. With the first named district he was exceedingly familiar, and medical experience had not only led him to form independently the same opinion as Mr. Atkinson, in regard to the organic impurities of the water, but several groups of cases had been carefully traced up to an evident origination from particular wells in that district. He was not quite prepared on the evidence before the meeting to accept as final the very ingenious and suggestive explanation proposed by Mr. Atkinson, for the ascertained fact of the increasing impurity of the water supply as it neared its final outlet. Where actual holes did not exist he questioned if diffusion through the water-logged sides of the wooden main would suffice to explain altogether the extensive contamination that seemed to take place. This part of the investigation seemed still to require experimental verification, but meanwhile he would venture to suggest a very much simpler explanation. The wells, as he had seen from examination of certain apparently poisoned ones, were supplied by a bamboo pipe leading off from the main which was always pervious and immersed in the water of the well. Now if any impurity should enter the well, it seemed to him that part of it would naturally regurgitate by the open supply pipe into the main, and thence be distributed in a highly scientific manner, though perhaps too diluted to be markedly injurious, over the remaining area of supply. An example of the danger thus arising may be interesting. Two people living in Odawara district, near the outlet of that supply which Mr. Atkinson showed to become progressively impure, sickened suddenly of cholera and died in a few hours. He found that both had drunk out of one well and out of that well alone. This well was connected with the main in the manner he had described. Its walls were decayed and admitted visibly of leakage. Separated by a few inches only was a deep trench filled with putrid stagnant filth from the houses, which had not, an official told him, been cleaned for years. The lining of this gutter was of decayed wood also. A few feet along, and *leaking visibly* into the gutter, was a public urinal and privy—not cleaner than the average ones in the slums of Tôkiô. Some of the filth from that place must almost certainly have got into the well, and from thence he thought into the main again. That this water, after all, was not to every one absolutely poisonous, was shown by the fact that the minor official accompanying him, who differed somewhat from his estimate of the safety of this arrangement, took a good draught of this beverage and he was happy to say survived. The danger, on the other hand, might be shown from the fact that the adjoining public privy had a very clear history of infection from choleraic discharges, and during an epidemic few of these places can escape infection. Cholera, however, is not the only disease which may thus be propagated. Diarrhœa, dysentery and typhoid are persistently prevalent in this district, and these have a close relation generally to the water supply Further, typhoid cases seemed to him clearly to have originated by contaminated water from particular wells in this part of the city. Mr. Atkinson's examination of the water at Suruga-dai had yielded results quite as valuable from a medical point of view, and results which to most were quite unlooked for and surprising. He might state, however, that an outbreak of a disease closely related to diphtheria in many of its features seemed to him unmistakeably to origiuate in Suruga-dai. It spread thence with a pretty clearly connected history of contagion from individual to individual over a large part of Tôkiô; Japanese and foreigners were equally and in several cases fatally affected. It was traced up to Suruga-dai, and with the utmost efforts could not be traced beyond there. As cases are even now appearing of a similar kind, he had had his attention directed very closely to this spot, and had inspected roughly one or two of the wells. The water did not appear very wholesome, certainly, but his doubts were somewhat stifled by the general impression prevailing everywhere that the water in such a situation must be better than in other parts of Tôkiô. The facts laid before the society to night, and arrived at without any knowledge of those he now mentioned, threw back a flood of light on this outbreak. He was aware that this disease had been called diphtheria, but as the characteristic membrane of that disease was wanting in all the cases seen by himself and by Japanese doctors who had spoken to him on the subject, he still hesitated to apply this term to these cases. It was a disease, however, he had no doubt, depending on a microscopic living and growing poison, which could be transferred from one favourable soil to another by water, although it might likely enough avail itself also of other means of diffusion. On one point not alluded to in the paper he would like to make an enquiry. He had been frequently struck with the prevalence of symptoms amongst the Japanese which strongly resemble, and even in some cases exactly simulate, those produced in chronic copper poisoning. Had Mr. Atkinson tested for copper? Of course, if these symptoms are due to copper, that might perhaps come from the vessels used for cooking, etc, which are frequently made from that metal. Such an accident happened to himself when passing through Kiôto. In a well known Japanese hotel much frequented by foreigners and well conducted, some soup was presented to him so strongly impregnated with copper salts that it could not be used. It would be interesting, however, to know whether even in the water-supply there may not be a faint trace of copper; perhaps it might be influenced by the rain-fall at the sources from which the water is drawn. He thought Mr. Atkinson deserved the thanks of all for bringing his conclusions so clearly before the Society. Nothing could illustrate the importance of a good, unpolluted water supply so well as the case of London during the cholera epidemic of 1854, and that of a poisoned well in Rochester (U.S.) last year. In a certain district of London two water companies supplied alongside of each other families living under precisely the same conditions, except that the water supplied to the one portion was derived from a higher reach of the Thames than the other and was much freer from sewage. Amongst these people the mortality from cholera was very slight. The water of the other company, drawn from a source near the city, was therefore impure from entrance of sewage. The families who used this water suffered to an extraordinary degree, and only one explanation seems available. The case of Rochester was similar but only one particular well was suspected. The illnesses among families who partook of its water were very numerous, while those living in the same neighbourhood, but using other wells, almost entirely escaped. It was now believed that many of those diseases which are so far spreading and fatal are due to the growth and diffusion of living seeds or germs, far too minute in many cases to be seen by any microscopic power we have yet been able to obtain, but some of them have been seen and others may yet be. It was, meanwhile, a safe and practical conclusion that water which was contaminated with filthy and infectious matter, might serve to transport far and wide these minute living sources of disease and death.

Dr. Divers wished to congratulate the author of the paper on the opportunity that had been afforded him for making a comprehensive investigation into the nature of the water supply of the city, and on the thoroughness with which he had availed himself of it. His own experience had been very limited, but he might mention that the results which he had obtained with the water at Tora-no-mon supplied to the Engineering College, agreed with those of Mr. Atkinson—the quantities of chlorides, ammonia, and nitrites being inconsiderable, and impurities readily oxidizable by acid permanganate solution absent. The non-scientific public were apt to be incredulous as to the significance of such small quantities of impurities as the chemist found in potable waters, but the experience of medical men had placed it beyond reasonable doubt. Respecting the quantities of nitrates and nitrites in waters, a statement had lately been made in England by Professor Lungo to the effect that by the method usually followed, and just described by Mr. Atkinson to the meeting, the amounts of these substances were under-estimated. Water was sometimes found, in summer time especially, to acquire an unpleasant taste, which excited distrust as to its wholesomeness, but this taste was often due only to the presence of minute quantities of substances derived from vegetable mould, and had not the evil significance attached to evidence of animal contamination of the water. He thought it quite possible that the water supplied through wooden pipes might become contaminated in its course by diffusion, through the joints of the pipes, if not through the substance of the wood. Although not connected with the subject of water-supply, still as bearing upon the dissemination of disease, he might point out the possible dangers of the careless and offensive method of portage of ordure from the city to the country districts. Direct experiments with chemical solutions in a state of effervescence had proved, that during the putrefaction of liquid ordure, particles must become suspended in the air and remain so for a considerable time, and thus be liable to be carried to great distances by the movements of the atmosphere.

After some observations from Mr. Ayrton and Dr. Veeder:

Mr. Atkinson briefly replied to some of the remarks made by previous speakers. He had attempted to gain some information respecting the parts of Tôkiô considered to be healthy or unhealthy, but had failed to get anything very definite. It was generally agreed that the districts of Yotsuya and Koishikawa were healthy, as well as Suruga-dai, whilst Honjo was considered to be unhealthy. That Suruga-dai should be a healthy district was contrary to the conclusions drawn from the analyses of the water, and Mr. Atkinson, therefore, felt gratified that his results were corroborated by Dr. Faulds, especially as his opinion was derived from utterly different observations. With respect to the pollution of the water being caused by infiltration into the wells and not by diffusion through the pipes, Mr. Atkinson considered that although regurgitation would probably occur, yet its extent would scarcely be sufficiently great to cause any very marked increase of impurity, and pointed again to the circumstance that the amount of impurity increased as the distance traversed by the water was greater, whereas, if the contamination took place in the well itself, the distribution would be irregular.

The President closed the meeting by remarking on the deep interest of the subject, and the useful manner in which it had been treated by Mr. Atkinson and those members who had joined in the discussion. The former had clearly demonstrated in his paper how important it was to the health of the people of this large city, that they should be furnished with better water than that which they now drink, while Mr. Chaplin had given most interesting details respecting the history and working of the present water system of Tôkiô. He had also shewn that an ample supply of the purest water was within easy reach, and that it was only owing to imperfect mechanical arrangements that such water was not conveyed from that fine stream—the Tamagawa—to the doors of the people entirely free from contamination. Allusion had been made in the paper to the new water-works of Glasgow, which were believed to be the most successful enterprise of the kind yet executed in the United Kingdom. These works had been laid out on a scale which would admit of a daily supply of fifty millions of gallons being furnished to a population of about 450,000, though twenty-six millions of gallons had been found sufficient to meet their wants. Mr. Chaplin had informed us that one hundred and fifty millions of gallons were drawn off daily from the Tamagawa, a fifth of which, however, was only brought to Tôkiô, and supplied to 350,000 people, or less than half of the population of the city. It would be seen, therefore, that the present supply from the Tamagawa, having regard to the number of people who used it, was on a scale scarcely inferior to that of Glasgow, although the large manufactories of that city created a particular demand that was not known at Tôkiô. As the supply from the Tamagawa could be increased to five times its present amount there was no question as to its sufficiency, and the only difficulty which lay in the way of placing Tôkiô in as good a position, probably, as any other city in the world, appeared to be the cost of substituting iron pipes for the existing defective wooden ducts. The estimate of a million and a half of dollars was a serious outlay, however, for the Japanese Government to have to face, and if the Committee of members who had undertaken to pursue the investigation of the subject could suggest any means for reducing this estimate without detriment to the quality of the water, they would render an important service to the Government and to the people of Tôkiô. He was glad that such a practical subject had been brought before the Society, and he particularly recommended it to the attention of the members.

Dr. Faulds hoped that experiments might be carried out to put to the test Mr. Atkinson's theory of contamination by diffusion, and he suggested that Mr. Atkinson, Dr. Divers, and Mr. Chaplin should be asked to give the subject their attention.

The President thought the suggestion a good one, and proposed that Dr. Faulds be added to the number, and that the Committee have full power to add to their number.

The meeting was then adjourned.

IMPROVEMENT

OF THE

CONDITION OF WORKMEN.

BY

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IMPROVEMENT

OF THE

CONDITION OF WORKMEN.*

THE improvement of the condition of workmen is a subject in which every one must feel the greatest interest. There is, however, something beside their mere physical welfare, which alone seems to be the object of the Hôtel Louise, which requires the most earnest attention. I do not know of any place where laundry privileges seem to be carried out in so great perfection, or where such special attention is given to the restaurant department as in the hotel belonging to the Hassard Collieries. These are, however, only insignificant items, so far as the general well-being of the men is concerned. Something requires to be done to elevate their moral as well as physical condition; and unless it is done, it is impossible to keep up their *morale* for any great length of time.

To ameliorate their condition, it is not sufficient to provide restaurants and laundries, although good food and cleanliness are very important moral as well as physical correctives. But the world cannot generally depend upon unmarried men, for whom these provisions are made at Hôtel Louise. It is generally conceded that, to keep a skilled or even an ordinary workman for any length of time in the same place, he must be married. He should be able to hope that his family, which is as dear, and, perhaps dearer to him, than that of persons occupying higher stations in life, will be reasonably provided for in case of his death; or that, if he is disabled by accident, there will be some expectation that he will either receive treatment which will cure him, or, at least, will render him as capable as possible, under the circumstances, of supporting his family. He wishes to be assured that his family will be provided for in case of sickness, that his children will be educated, that his dead shall have a decent burial. In those establishments where the best work is obtained, some kind of rational amusement is provided, which not only elevates the tone of the society which surrounds him, but keeps him with his family, and, what is quite as important, from worse things. It is not always possible to combine all this in any one institution; nor are they anywhere combined, but each one separately does exist in the highest state of perfection in different parts of Europe. As a student, my attention was very early called to this subject, and the condition of the working people has been a subject of great interest to me ever since.

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* At the meeting of the American Institute of Mining Engineers, held in New Haven in February, 1874, Prof. Blake described the restaurant, hotel, and laundry arrangements of the Hôtel Louise, at the Hassard Collieries, near Liege, in Belgium. This paper was part of the discussion of the general subject of the improvement of the condition of workmen which was followed.

The establishments for ameliorating the condition of workmen differ in different countries. Most of them have been founded for the sake of keeping the men quiet and satisfied wherethey are. No one is applicable in this country as it exists abroad. There are too many races here, each one of which has its own national customs and amusements, and they refuse as persistently to blend as oil and water.

In the Georg-Marien Hütte, in Hanover, each workman is provided, at a low rent, with a house built of slag brick, which is of a gray color, and is light and singularly free from dampness, and makes a house of exceedingly pleasant exterior aspect. These houses are arranged for families of different sizes, and their interior is in every way comfortable and commodious. They have each a cellar, and are one story and an attic high. Every attention is given to their proper sanitary condition, and their arrangement in streets is most convenient. The plans of these houses attracted very great attention at the Vienna Exposition, and I think, on the whole, are the best of their kind, furnishing a comfortable, commodious home, where more than ordinary sanitary regulations are carried into effect. In certain parts of Austria there is a choice in such houses, the best being given to those married men who have been longest in the works, and who have had the least complaint made against them for abuse of the sanitary laws.

Of the mere matter of houses, these form the two most conspicuous examples that have fallen under my notice. Under such conditions as these, where houses are furnished, the restaurant system becomes impossible; and it is doubtful whether it is desirable, except in the case of unmarried persons, who are, in Europe, almost always transient men, and, therefore, are not a very desirable class. The part of the old Guild system, which requires that the workman shall travel, is still in moral force, from the fact that it has become a custom, though the *Meisterstück* is no longer required, and there are consequently a considerable number of transient workmen who use the time they remain in works for their own benefit. With the modern system of rapid travel the transient workman is generally a very demoralizing element.

It is characteristic of almost all the German works, where the system of looking after the workmen is carried into effect, that they provide some kind of rational amusement. The best types of these are at Georg-Marien Hütte, where the workmen have a small *Bier Garten*, and have beer furnished to them at cost price, and where they have also a theatre and a concert hall. The actors and musicians are composed exclusively of workmen. I visited this theatre and *Bier Garten*, and examined it in detail, and I was told by the director of the works that the musical and theatrical performances of the men were creditable in the highest degree, and that the families of the officers of the works were in the habit of visiting the theatre and concerts as a matter of amusement; and that since the erection of the theatre there was an appreciable elevation in the condition of the men. The bier-garten system, or the pleasure garden of the Anglo-Saxon, is most extensively and completely carried out in Borsig's Works, in Silesia. A garden, comprising a number of acres, laid out in the most artistic style, and planted with trees and flowering shrubs, is provided by the works. It is arranged on the same general plan as the pleasure gardens of the great European cities, but, of course, not so luxuriantly fitted up. This garden is provided with the ordinary amusements for children, with handsome arbors and shade trees; and on holidays a band of music, composed of workmen, plays at stated intervals. All kinds of amusements, for grown people as well as children, are provided, such as is usual in gardens of that character in Europe. All the buildings are decorated artistically, and are filled in the evening and on holidays with men, women, and children, including the families of the officers of the works. On special occasions there are grand demonstrations of music, and special decorations of the gardens, all of which are carried out by the men, under proper direction. Such a garden as this, filled with families engaged in all kinds of harmless recreation, goes far to make the men and their families respectable, and is certainly an interesting spectacle, which, unfortunately, cannot often be seen in any country inhabited by Anglo-Saxons. Its influence is seen directly, in the product of the works. The men rarely leave of their own accord, and their general *morale* is no small part of the reason why the works turn out some of the highest grades of iron manufactured in Germany.

The free hospital and school systems are carried out in their greatest perfection in England, where day and night schools have been established by the proprietors of some of the works, under the direction of clergymen and government schoolmasters. I became so much interested in some of these schools, that after examining them in a good deal more than the ordinary routine of arithmetic, etc., I offered a prize for a written examination on subjects which I proposed to them, and these examinations were afterwards sent to me. The children of this school, which was a day school, were none of them over thirteen or fourteen years of age. The examinations would certainly have done credit to the lower classes in our colleges and the universities abroad. The night schools were attended principally by persons over the age of sixteen. The parts of these schools which principally attracted my attention were the drawing classes; they were organized to teach not only free hand sketching, but to some extent geometrical and mechanical drawing. The interest excited even among the older workpeople of both sexes was surprising, and their performances highly creditable. The schoolhouses are so arranged as to be easily transformed into a church on Sunday, and I certainly never saw a more quiet and devout congregation than that assembled there for worship. I visited the families in their homes with the clergyman in charge, and as is not unusual in England, I frequently found that the grandfather of the family had been a workman in these same works, and the grandson was looking forward to the same position. There was connected with these works a hospital system, a physician being paid by the works, and the men allowed the liberty, in all ordinary cases, of being treated in a hospital building or in their own homes. A system, which I have seen nowhere else, was adopted here with reference to boys who had become maimed in the works so as to render them unfit to become workmen. They were specially trained to occupy office positions, or educated for occupations suited to their condition. One of the brightest boys I saw had lost a leg by some accident about the rolls, and was being trained to occupy the position of bookkeeper. My attention was specially attracted to these works because I had gone to Staffordshire to ascertain how their iron was made, as it was of superior quality, and much better than that of their neighbors who were using the same materials. My impression, of course, was that the superiority was owing to some peculiar process. After visiting the works carefully I saw nothing in any way different from the other works of the neighborhood, and I became convinced that the whole secret lay in these excellent arrangements for elevating the moral and physical tone of the workmen. The proprietor of these works informed me that he had spent £30,000 in the erection of the necessary buildings, and in carrying out the plans, which were the most perfect that I saw in England; and I am certain that every penny of the capital so invested came back to him, in the superiority of the work done in consequence, every few years.

In France the hospital system—for the school system was not formerly in favor—is carried out mainly by the workmen themselves. A society of the workmen is formed, of which the director of the works is president. Members chosen from among the workmen by ballot are associated with him as a council or board of trustees. A certain part of the funds necessary is subscribed by the company, the rest is raised among the workmen themselves, by means of a tax on wages or by fines. These fines are established for such things as coming to the works intoxicated, arriving late, unnecessary neglect, and, in some cases, for profanity, etc. The workman declared sick by the physician in the employment of the company receives so much per day from the common fund. In case of death a portion of the funeral expenses is paid by the society and the works together, and the widow receives a pension, graduated according to the position of her husband and length of time he had been connected with the society or the works. Persons disabled by sickness or age receive a pension, to provide for which a certain percentage of the wages received by every workman is retained by the society to create a pension fund. Any workman discharged for incompetence or neglect, or who voluntarily leaves the works, loses all right to any part in the administration of this fund. In case he should return, he commences, except under special circumstances, as if he had never been connected with the works.

I have been convinced for a great many years that the workman does the best where he is most kindly treated, and where he can look forward to some reasonable support for his family in case of his death or inability to work.

When I first returned to this country I hoped to put some of these schemes into practice, and I commenced with more enthusiasm than judgment to apply a system drawn from my experience in England and the Continent to Celts, with not very fortunate results. They were suspicious of the houses that I built, were certain that I was personally deriving benefit from the fines that I proposed for the foundation of their fund; were jealous of their own members, raised to higher position than themselves, as they thought, by being brought more in contact with the officers of the company than they were, and caused so much trouble that in the interest of the company I was obliged to abandon any attempts to elevate the condition of the men, and I must confess that I have been obliged as conscientiously to abstain from acting as I was at first disposed conscientiously to act.

The short time that can be allowed to the discussion of any question like this by the Institute is greatly to be regretted, not only because anything that can be done to raise the condition of the workmen, necessarily increases the product, but also because there is a greater humanitarian interest in elevating the moral and physical welfare of our own people and our adopted countrymen. Unfortunately our religious and political differences greatly aggravate the difficulty. I believe it, nevertheless, to be true that some plan may be devised which will work successfully with the various nationalities which we are obliged to employ as workmen. The chief trouble with them all, as far as they have come under my notice, is that, as a class, the men engaged in mining are improvident, and that they are addicted to the use of the stronger alcoholic stimulants. If they used good liquors in moderation there would be little objection. The difficulty, however, is that the liquor which they buy in preference is cheap, and that, as a general rule, even if they should try to purchase good liquor the cheap article would be furnished to them at a high price. This cheap liquor contains so much fusel oil as to endanger the constitution of the men and make them more unmanageable than they would be if inebriated simply by alcohol. To furnish the men with good liquor at a low price, or at least liquor which did not contain fusel oil, would strike me as being one of the means of remedying the real evil. I cannot pretend to say how this should be carried out or regulated in each particular case. The German would certainly be content with good beer, and if he understood that better beer was furnished to him for the same money he would take that in preference; while the Irishman would probably want something which scratched all the way down which could be furnished him without the poison. Whether it would be worth while for any company to undertake to inspect the liquor sold to their men is a question. Those who have large works have probably tried the experiment of regulating the sale, and know more about it than I can suggest, but it is a matter of real moral and physical importance that some method should be devised by which workmen should be prevented, if possible, from drinking liquors which, from their method of manufacture, must be more or less poisonous. We cannot prevent their use of stimulants and I therefore think it is better that, since they cannot be prevented from drinking, a good and always pure liquor should be furnished them, and that they should be furnished a better article than they can buy at the same price, which can only be done by those who have no interest in making money out of them.

I cannot pretend to give a remedy for the improvident character of the miners, except it be to encourage marriage among them, and I do not feel certain that even this would be effectual; but it seems to me that some plan of furnishing them comfortable, commodious, well-drained and ventilated houses, provided with plenty of good water, would be an efficient means of keeping them at home.

The question of education is provided for much better in this country under State laws than it is in any of the countries of Europe, and I do not know that it would be wise for any company to interfere further, than perhaps to see that the State system was really carried out.

The matter of pensions, hospital relief, etc., has been taken up so much by societies among the workmen in this country that it would seem, perhaps, a difficult matter for any company to interfere in any way with it. I am satisfied, however, that if any plan could be devised by which the society could have as its officers members of the company, who would show in their meetings a real interest in the welfare of the men, that would go far toward destroying the influence of demagogue workmen upon their fellows. I am not prepared to furnish any plan for such a society, nor am I at all sure that such an organization would be possible. This class of people are difficult to treat with, and my experience of many years' charitable work among the poor has shown me that the great difficulty in reaching them is not so much the kind of treatment or the distribution of alms as their suspicion of you, for they are, as a general rule, slow to believe in disinterested motives. I make these suggestions with diffidence in presence of persons largely engaged in manufactures, and who have so many men working under them, on account of my great interest in the subject, because I have become convinced by long connection with charitable work that a great deal of our charity makes beggars, and that there is a great deal of misdirection in the philanthropic work undertaken to elevate or relieve the classes known as the working classes. It is much easier, I know, to find fault than to carry out plans for relief, or even to suggest some practical method for effecting the object in which we are all so greatly interested.

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